Railway Signaling In Theory And Practice

James Brandt Latimer

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In

Theory and Practice

By

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TO THE SIGNAL ENGINEERS
OF AMERICA THIS BOOK IS RESPECTFULLY DEDICATED
BY ITS AUTHOR.

AUTHOR'S PREFACE.

In the ensuing pages, it has not been my intention to treat the subject of railway signaling as practiced in America in anything but an elementary way. Even the elements are not always readily grasped by persons who have not had some practical railway experience, and are at least somewhat familiar with the ordinary methods pursued in constructing tracks, moving trains and in the nomenclature used by those whose daily life is spent in actual railway operation.

My object has been to supply a want which I myself felt sorely at the beginning of my career as a Signal Engineer—that of an elementary text book bearing on the subject.

The matter was originally compiled with a view to publishing it serially, and indeed nearly one-half of it has already appeared in that way. Although I have taken as much time as it was possible for me to spare from a busy life to arrange and revise the matter in proper form for its present appearance, I cannot but feel that I may have left a great deal yet to be done. I can only say that I have tried to do my best and that I hope the book will be well enough received to give me a chance to make any revisions which may appear advisable in a later edition.

I have taken the liberty fully to express my own opinions where I have thought necessary, and have always endeavored to impress on the reader's mind that they were such so that he could take them for what they are worth.

After more than eighteen years spent in the operating department of a large railroad, and nearly seven years as its Signal Engineer, I cannot but feel that these opinions must be worth something now if they ever will be. The reader must judge for himself.

I wish to take this opportunity of acknowledging much valuable assistance in collecting matter and preparing illustrations rendered me in this work by Messrs. Theodore C. Seifert, Frank Lyman Beckwith, Charles W. Breed, and Wm. F. Zane.

I shall be glad at any time to receive suggestions from any reader for the improvement of the book.

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CHAPTER I.

INTRODUCTORY.

Webster defines the word signal as meaning, "A sign used for the purpose of giving notice to a person of some occurence, command, or danger."

As applied to railroad operating practice, this definition appears to cover the ground completely.

Broadly speaking, railway signals may be divided into two grand divisions: Fixed signals, in which is included any form of signal permanently placed in one spot—as semaphores, switch targets, whistle boards, etc.

Other signals, in which is included any form of signal not of a permanent nature, as a flag or lamp in the hands of a flagman, or a torpedo placed on the rail to warn engine runners of temporary danger.

Engineering practice in connection with signals may be said to be confined to fixed signals only, although the drawing up of specifications for colored bunting for flags, and for colored glass for lamp globes and lenses, and the testing of such articles after purchase would, and most frequently does, fall upon one branch or another of the engineering department.

I shall, however, confine my further remarks to fixed signals only.

This class may again be sub-divided into two other classes, visible and audible.

In the former class would be included semaphores, switch targets, and the like, with their lamps at night, and in the latter class, highway crossing alarms, annunciators to warn levermen or others of the approach of trains, and torpedoes placed by torpedo machines.

In American practice little, if any, general use is made of the audible fixed signal as a means of conveying information to those employed in running engines. The torpedo machine has a limited use as an auxiliary to call the attention of enginemen to the fact that they have disregarded a visual signal, and at some stations trains are started by gongs or fixed whistles, but these cases are more often the exception than the rule.

Visual fixed signals may again be sub-divided into two classes: those which change their aspect and those which do not.

The former class would include semaphores, disc signals, switch lights, etc., and the latter class, whistling boards, slow signs, water tank signs, etc., etc.

From this on I shall omit reference to this latter class.

The former class may again be divided into three minor classes:

(1) Those which indicate routes, the position of switches, etc.

(2) Block signals.

(3) Train order signals.

For the purpose of elementary instruction, this classification cannot be too strongly impressed on the student's mind.

Under No. 1 we should consider signals at interlocking plants, switch targets, and any one of the myriad types of signals used for drawbridge and cross-

ing protection when interlocking is not used. For interlocking purposes the semaphore signal, Fig. 1, is in almost universal use.

It is generally used for two purposes, called (1) the home signal, (2) the distant signal. The home signal is that which really gives the indication by which the engine runner is governed. The distant signal is used simply to forewarn him of the position of a home signal. Until recently the almost universal practice was to have home signal blades

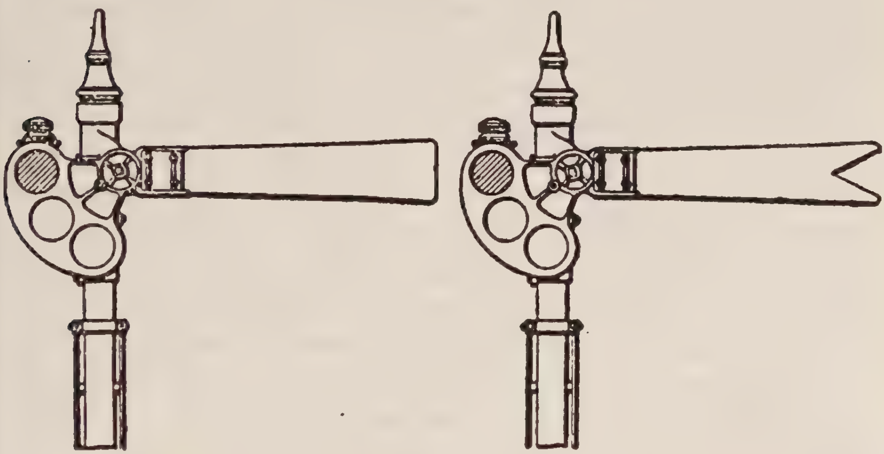


Fig. 1.

square ended, and distant signal blades with a crotched or fish-tail end, Fig. 1. Most generally the home signal blades were painted red and the distant signal blades green.

It is regrettable that there is not the uniformity in this which could be wished for. Some years ago the Pennsylvania Railroad, using the argument that, as a semaphore blade retained its color always, and that it was bad practice to allow engine runners to pass a red signal under any circumstances, decided to paint all its blades, both home and distant,

yellow, and to depend on their shape to distinguish one from the other. Later several other companies adopted this system. The more general practice, however, has been to retain red for the home signal blade.

As the semaphore is purely a position signal and the color has nothing to do with the indication it is intended to give, I have always thought that we might as well, for the sake of uniformity, all adopt the Pennsylvania plan, but, so far, little or nothing has been done along that line, excepting by roads more or less closely connected with the Pennsylvania.

During the last few years there has been a strong movement in favor of doing away with the so-called white light for a clear indication at night, and substituting therefor a green light. On roads which have made this change, in most cases an orange-yellow light is used for caution, and distant signal blades have been painted yellow.

The Chicago & North-Western is an exception. That company adopted a green light for clear several years ago, and uses a red and green light side by side as its caution indication.

Generally speaking, a home semaphore blade in the horizontal position means "stop," while a distant semaphore blade in the horizontal position means "caution," or proceed slowly, expecting to find the home signal at stop.

Of late years there has been a movement led by the Pennsylvania to have three positions for the semaphore blade:

Horizontal—"Stop."

Inclined at an angle of 45 degrees—"Caution."

Vertical—"All clear—proceed."

These indications may be given either in the upper or lower right hand quadrant of the circle

which the blade would describe with its free end if revolved on the pivot holding the fixed end.

Some few installations have been made where the upper right hand quadrant is used, mostly within the last few months. With the three position signals it is possible to carry the principle of position governing to a logical issue, as the distant semaphore has only the caution (inclined at 45 degrees) and clear (vertical) positions while the home signal has only the stop (horizontal) and clear positions.

The student should thoroughly understand what a good many signal men do not appear to grasp, that the *blade* of a semaphore is the signal. Two or even three blades are frequently put on one mast, but each is a separate signal.

As regards interlocking, I shall say little here, as I could not go into the subject in any detail without going far beyond the limits of this introductory chapter. But later on I will endeavor to treat it as fully as it is desirable. Suffice it to say that by the interlocking arrangement the switches and signals can only be moved in such a way that a train is insured a safe passage over some dangerous place like a switch, drawbridge, crossing or junction if the signals authorizing it to proceed are so displayed.

The designing of interlocking is the most important and also the most difficult to acquire of any part of a signal engineer's duty, and any person contemplating the taking up of signal engineering should make a special study of this.

I will say, before passing on, that the switches, signals, etc., controlled by an interlocking plant, may be moved by manual power, compressed air or electricity, but the principles of the interlocking are always the same. An interlocking plant is always

controlled by an operator, or leverman, as he is generally called. There are no automatic interlockings.

Route signals other than semaphores, such as switch targets and lamps, are of so many designs that they cannot be described. It may safely be said that they are all crude and that there is no reason, except the expense, why semaphores cannot be used, for all purposes where fixed visual signals are required, thereby at one step doing more to standardize signal practice in the United States than has ever been done before.

"'Tis a consummation devoutly to be wished."

We will now consider block signals. To the public this name means everything. To the signal engineer it means simply the signal which tells an engine runner whether or not he may proceed into a block. The reader is doubtless familiar with the definition of a block, so I shall not take space to explain it.

Block signals are of two general types:

Manual: Those which are operated by a person whose duty it is to do so.

Automatic: Those which are operated automatically by the train itself.

In all cases semaphore signals may and ought to be used for block signals, though the first form of automatic signal was a disc, and many of them are still in service.

Where manual block signals are used, the block operators are stationed at convenient places along the line to operate them. Each man communicates with the operators at the other end of the two blocks adjacent by telegraph, telephone or in some cases by bells.

Frequently an arrangement is made by which each operator, by the act of clearing his signal

electrically locks the signal at the other end of the block in the stop position. This is then called controlled manual block, and sometimes it is so arranged that the train automatically sets the signal at danger behind it and holds it at danger during its passage through the block, and it takes the operator's action to again clear the signal for another train after the first one has passed out of the block. This is the semi-automatic block, and, in my opinion, is the best and safest.

There is a type of manually controlled block known as the "staff system," of which a more detailed description will be given later. It is in reality a development of the first crude method of blocking trains and has stood the test of seventy years' service in Great Britain, where it is in general use on single track lines, but in the United States there are few installations.

Automatic block signals are all operated by a track circuit. The track circuit is simple and will be explained in detail further on.

Suffice it to say here that a section of track of suitable length (this to be determined by conditions of ballast, etc.), ranging usually from 2,500 to 5,000 feet, is electrically separated from the track on each side of it by putting rail joints, which are insulated with fiber, on each end of the rails on either side. The rails in the section are bonded together by wires (usually No. 8 galvanized), riveted into the ends of the rails so as to make a continuous path for the electric current. A battery, usually two cells of gravity, is connected to one end of the section, one pole to the rail on one side, and one pole to the rail on the other. In this condition no current flows as there is no connection between the rails. At the other end of the section, therefore, a low resistance (usually 4 ohm) relay

is connected to the rails so that the current from the battery flows through it.

Now if a pair of wheels enters this section of track the current of the battery, taking the path of least resistance, crosses from one rail to the other through the axle instead of the relay, and leaves the relay unenergized. Its armature falls back by gravity, thereby making or breaking a local circuit which operates the signal, or in some cases opening a valve which admits compressed air or gas under pressure to a cylinder which operates the signal.

There are hundreds of signal circuits, but the track circuit is always the same.

I will not discuss the difference between normal clear and normal danger automatic block signals, further than to say that in the former the signal is normally at clear and goes to danger as a train passes it, while in the latter the signal stands normally at danger, and goes to clear *if the block which it governs is clear* as a train approaches it, and to danger after the train has passed it. Each system has its adherents. The normal clear seems to have the best of it now.

Train order signals frequently are, and always should be, though in old installations many forms of discs were used, of the semaphore type. They are used to advise engine runners when dispatcher's orders are to be given them. They are always manual signals to be operated by the telegraph operator who takes the train order.

Where manual blocking is done, they (the train order signals) are used as block signals also in most cases.

One word about night indications. In all cases a red light means stop. Where a white light is used for clear, green is used for caution, but where

green is used for clear, as explained earlier, either yellow, or red and green together, means caution.

It is good practice, and frequently done, to use distant signals with block or train order signals as well as with route home signals.

So much for an introduction to a more detailed description of each of the general heads mentioned, which we will now proceed to place before the reader.

CHAPTER II.

GENERAL.

A word may as well be said here with reference to the plans or drawings used by signal engineers.

At the present time I shall not give a complete list of the conventional signs used by signal draftsmen to designate the various apparatus. The Railway Signal Association and the Engineering and Maintenance of Way Association have adopted a set of conventional signs, which has been issued in pamphlet form by several of the leading signal companies, and is procurable from them, but as we advance the signs called into use by each step will be explained and used thereafter in this work.

As a rule it will be found that track plans drawn to a scale of one inch on the plan equals one hundred feet on the ground are of a very convenient form. On some drawings requiring a great deal of detail a scale of one inch on the plan equals fifty feet on the ground may be found convenient. Scales such as one inch equals twenty or thirty feet are not to be recommended. As will be explained later, plans for long stretches of track showing a block signal arrangement may with propriety be drawn to a much smaller scale, one inch equals a thousand feet or even a mile, for instance, but the branch of our subject now before us is route signaling, so that we will confine our present remarks to the plans used therewith. These plans, as before stated, can generally be drawn to a scale of

1″ = 100 feet, and in exceptional cases of 1″ = 50 feet.

In designing the route signaling for any given point the signal engineer first draws up his "track plan," which is merely a map of the locality where the signals are to be placed, drawn to the accepted scale, and showing all the tracks, switches, crossings, etc., in the vicinity. It is not desirable to go into topographical details. In fact, all cuts, tunnels, bridges, culverts and buildings that do not have a direct influence on the construction of the

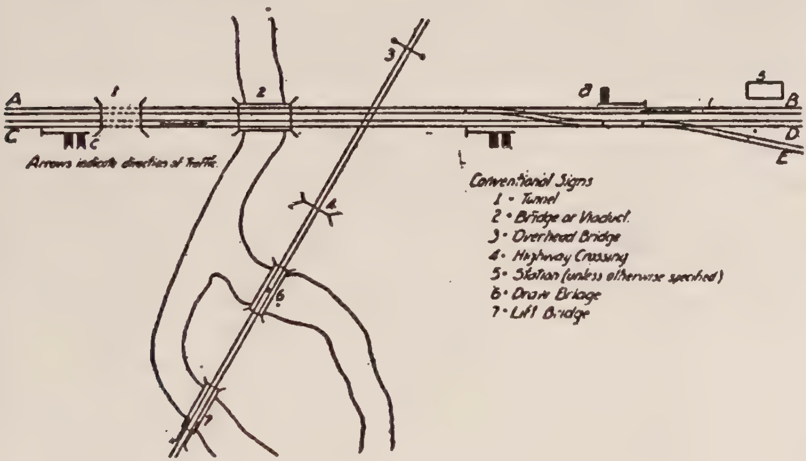


Fig. 2.

signaling apparatus had better be omitted, as showing them on the plan serves only to complicate it, and requires an unnecessary expenditure of the draftsman's labor. Water cranes and water tanks, coal chutes, station buildings and platforms had, as a general thing, better be shown.

Fig. 2 shows a double track line crossed by a single track line, a crossover between the two tracks of the double track line and a junction of a single track line all drawn originally to a scale of one inch equals one hundred feet, with a tunnel, a bridge, an

overhead bridge, a highway crossing, a drawbridge and a lift bridge, all shown in the conventional way as recommended by the Railway Signal Association and the Engineering and Maintenance of Way Association. In addition thereto, it may be noted that a semaphore signal is shown at "a," also in the conventional manner. The arrow just to the right of "a" indicates the normal direction of traffic (the direction in which trains are supposed to run) on the track shown as A B. It should here be thoroughly grasped by the student that the conventional manner of showing a semaphore on a track plan is as if it was laid down on the ground with its base towards a train approaching it in the normal direction of traffic, or in the case of a single track line, in the direction in which a train approaching the signal from its front would be moving, and its top (that end nearest which the blade is placed) away from an approaching train. The distinction between the front and the back of a semaphore will be explained more fully further on.

I have noticed that a great many persons, some of them competent engineers, overlook this fact and draw semaphore signals just the opposite way, which, being contrary to accepted practice, is wrong and can only expose the person who does it to ridicule or perhaps do him an injustice by giving an impression to a better informed person that he is entirely ignorant of the subject of railroad signaling, when in reality he may be well informed except on this one point.

Besides the distinction already referred to between a home and a distant semaphore signal there is yet another type of semaphore known as a *dwarf signal.* This is used always as a home signal. It is like a home semaphore signal in miniature when operated by manual power; when

operated by other power such as electricity or compressed air, the operating mechanism which is usually placed in a case which also serves as a post to support the blade, occupies so much room that it requires a considerable stretch of the imagination to detect the resemblance between this signal and a high semaphore.

Where it is advisable to have a high and a dwarf signal close together the saving of a separate post or mast, as it is generally called, for the dwarf signal is frequently effected by attaching a small blade to the mast of the high semaphore signal. When this is done this blade is usually placed ten

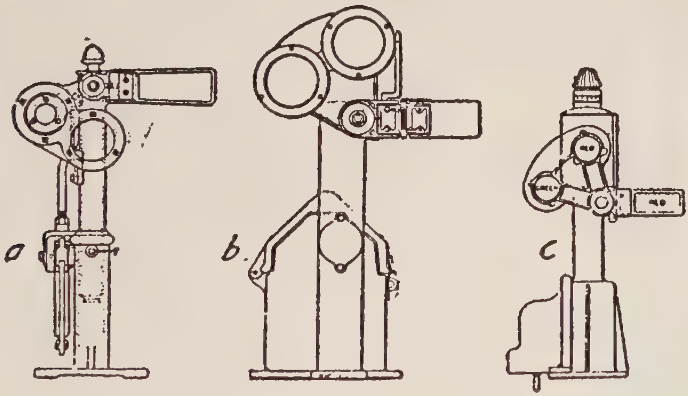


Fig. 3.

feet above the ground. The lowest blade of a high semaphore is placed twenty-five feet above the ground. Where a separate mast is used for a dwarf signal it is rarely more than three feet high.

Fig. 3 shows, a, a mechanically operated dwarf signal, b, an electrically operated dwarf signal, c, a pneumatically operated dwarf signal, and, d, Fig 3a, a high mechanical semaphore signal with small low blade in lieu of a separate dwarf signal. High semaphore signals, both home and distant, dwarf signals, and an innumerable variety of discs,

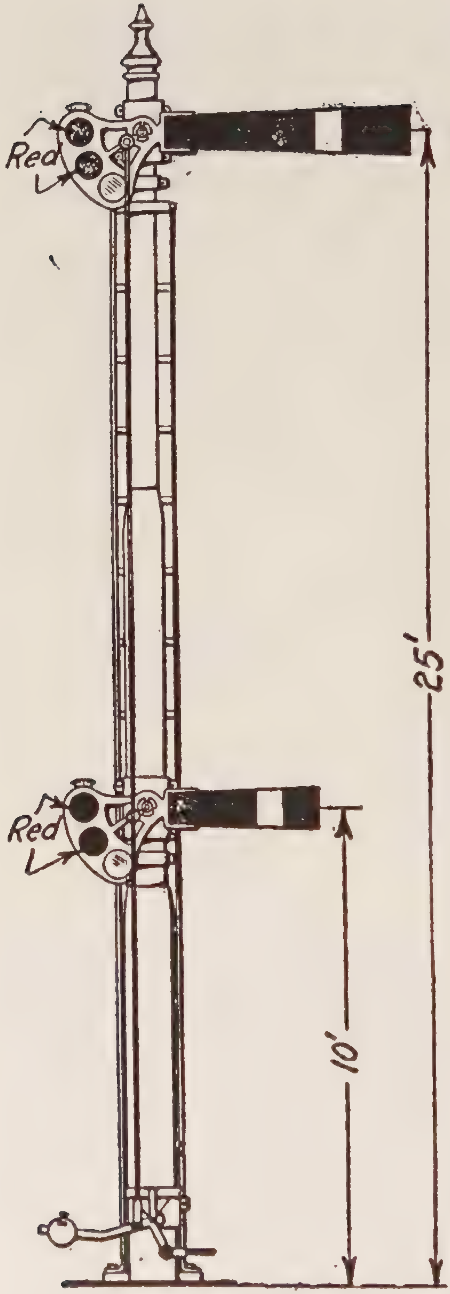


Fig. 3a.

targets, etc., are used as route signals, the latter principally on switch stands, but sometimes in old installations to govern the movements of trains over crossings and drawbridges.

I shall now discuss the use of semaphores as route signals and say a few words later about the other types.

Turning again to Fig. 2 the reader will see that on the right-hand side, facing in the direction of traffic, of track C D to the left of the junction switch I have shown a semaphore with two blades. This is to govern the two routes which may be given by the junction switch. When a two-bladed semaphore is used it is the accepted practice that the upper blade governs the superior and the lower blade the inferior route, but the distinction between the superior and inferior routes may be a purely arbi-

trary one where, as in the case of a junction on either line of which the traffic is of about the same kind and importance, it would be a difficult matter to decide which of the two lines was the more important.

✓ Generally, if one line is straight and the other diverges from it by an ordinary turnout, as in the case of the single track line shown in the figure, the straight line is considered the superior route, and I shall so consider it here. If, therefore, a train is moving from C towards D and the upper blade of this signal is at clear, the engine runner of the train knows upon coming in view of this signal that the person controlling it intends him to proceed on this route, and it is, therefore, unnecessary for him to slacken speed, and, as it were, feel his way, as he would be forced to do if there was no signal to give him this information.

If, on the contrary, this same engine runner finds the upper blade in the stop position, but the lower blade clear, he will know at a glance that he cannot take the route to D, and must, if he proceeds, take the diverging route to E. If, of course, he knows that he cannot reach his destination by taking the route to E, he will know that this route is not intended for his train, but that the person controlling the signal has probably mistaken his train for another which should be sent forward via route to E, and will stop his train and have the route changed before proceeding, even though the signal has shown him that he may proceed with safety towards E.

If, however, he finds both blades in the stop position he perceives that the person controlling the signal does not wish him to proceed by either route, and that he must consequently stop and wait until the proper signal is cleared.

These three cases cover all the information that can be given by a two-position home route signal, viz.—proceed by the superior route—proceed by an inferior route—stop. I would call the reader's particular attention to the wording of the second case. There I have said "proceed by *an inferior* route." In early installations in this country it was not uncommon to have three or even four high signals on one mast, and although it is not now considered good practice to display more than two, the lower one may govern more than one route. Cases where it is necessary to govern two or more important routes by one signal do not occur often, and can quite generally be avoided by the use of an extra signal.

Careful experiments made at various times have proved beyond doubt that even with the improved train brakes used on railway equipment it is not advisable to consider that the heavy trains now being run at high speeds can be stopped on an average in less than 2,500 feet from the time the brakes are applied.

In the case of route signals giving the stop indication it is necessary that an engine runner should stop his train before passing them, so that, for one reason, they will be within his range of vision when they are changed to the proceed position. Permanent, natural or artificial conditions, such as woods, hills, buildings, etc., may render it impossible for an engine runner to see a home signal 2,500 feet before reaching it, and temporary conditions, such as rain, snow or fog, may occur with the same result at any time. In order, therefore, to enable an engine runner to get his train under such control that he can stop before overrunning a stop signal, distant signals as shown at "c" in the figure are provided. It is good practice and

at present is being quite generally done to provide a distant signal for each high home signal, although formerly it was the more general custom to provide only one distant signal which repeated the superior route home signal and stood at caution when the inferior route home signal was cleared. The assumption being that the inferior route being a diverging one, as it is in most cases, should be taken slowly anyway, and that an engine runner coming up to a distant signal at caution would put his train under control in preparation for a stop at the home signal, which would insure that he would then take the turnout at reduced speed, while on the other hand, if he was given a clear distant signal, showing that the route, even though the inferior one was clear, he might not slow down, and would take the turnout at a higher rate of speed than would be safe.

At the present time when frogs of as acute an angle as No. 24 are in common use in main line turnouts, this objection to a distant signal for each home signal ceases to be such a cogent one, and, as before stated, the best practice nowadays is to provide the additional distant signal.

The reader should note that in speaking of a distant signal I have used the word caution position. A distant signal proper has but two positions, caution and proceed. In the original two-position signal systems in the caution position the blade of the distant signal was horizontal, which was the same position as the stop of the home signal, the distant signal being distinguished from the home by its color and shape—usually having a V-shaped notch cut in its end. This has led a great many people who should really know better to carelessly speak of a distant signal in the stop position, an inaccuracy which should be carefully

avoided, as it is very confusing to people who are not thoroughly familiar with the terms used and uses of the various signals.

A home signal in a two-position system has but two positions—stop and proceed—but in a three-position system it has three positions—stop, proceed cautiously and proceed without limitation. This will be gone into more fully later. At present we shall confine ourselves to two position signals.

We next come to the use of dwarf signals. Unfortunately there is not the same uniformity of practice with their use as there is with high signals, some signal engineers preferring to use high signals where others use dwarf signals. It may generally be said that dwarf signals are always used for reverse or back-up movements on main tracks. That is, on a double track line where it is necessary, as at a crossing, to have a signal which would only govern a train backing up or moving in the direction opposite to the normal direction of traffic on that track, a dwarf signal would be used. Most generally, too, where there is a crossover between two main tracks the route through it is governed by a dwarf signal. The difference of opinion has arisen over the question whether it is better to govern the routes from main tracks to passing tracks or yards with dwarf or high signals.

It should be here understood that the use of a dwarf signal in the particular case now referred to is that where it is used in conjunction with a high signal, either by placing a small blade ten feet from the ground on the high signal mast as before described, or by using a dwarf signal placed at the base of the high signal.

Fig. 4 will serve to illustrate this. A train moving from A in the direction of the arrow would be given distant signal 1 and home signal 2, if

it was to continue along the main track towards B. If, however, it was to take the siding, distant signal 1 would be held at caution, home signal 2 at stop and dwarf signal 3 would be cleared.

Several years ago when signaling in this country was in its infancy high signals were more frequently used for this purpose. As railroad signaling came to this country from Europe and was first applied where traffic was most dense, viz., in the east, eastern signal engineers appear to have become accustomed to the use of the high signal. In the west, where the whole art of signaling is of much more recent date, the dwarf signal appears to

Fig. 4.

be preferred. My own preference is for the dwarf signal. It cannot be seen from any great distance, and as it has no distant signal and the distant signal for the high home signal is at caution, an engine runner on coming up to the distant signal, being unable to see the dwarf, must get his train under control and must have slowed down to a speed with which he may enter the turnout with safety by the time he comes in view of the dwarf signal.

I have known cases where the signal for this move has been given by a lower high arm which in clear weather could be seen from the distant signal in which the engine runner, seeing this lower arm clear, has failed to slow down and has entered the turnout at such a rate of speed as to cause a derailment. These turnouts are most frequently taken by freight trains in which there is always likely to be a car unevenly loaded, which increases the liability of its being derailed when

suddenly brought into the sharp curve of the turnout at high speed.

For fear that some reader may be misled into believing that there is a contradiction between the position I have here taken in regard to the use of distant signals (see page 23) and in regard to the use of dwarf signals, I want to say in explanation that the two cases are not parallel. What I said in regard to the distant signal referred to the divergence of two or more high speed routes, and though one is designated the superior and the other the inferior, they are all constructed in such a manner that trains may take any one of them at speed, but in the case of the side-track movement, where the use of a dwarf signal is preferred, the route is one not intended for fast running. The frogs of the turnouts are anywhere from Nos. 8 to 12, and the track beyond is generally constructed purely for low speed use. It is, however, just because there is an apparent similiarity between the two cases that the difference of opinion as to the use of the dwarf signal has arisen.

It quite frequently occurs that there are two or more reverse and low speed routes diverging from points so close together that one dwarf signal can govern them all, as for instance, a side track leading from one track of a double track line by a facing point switch and immediately behind its frog a facing point crossover between the two main tracks. In such cases it is the more general practice to let the one dwarf signal govern both routes. It is, however, permissible, and in some cases quite desirable, to have two blades on the dwarf mast. More than two blades, however, should never be used.

This is shown in Fig. 5.

In such cases there is no fixed rule as to which

of the slow routes is the superior, and the upper blade may govern either of them, at the option of the signal engineer.

Besides the semaphore type of dwarf signal heretofore referred to there is what is known as a *pot* signal. This is made to revolve on a vertical shaft like a switch target, and is generally connected di-

Fig. 5.

rectly to the points of a switch, the route through which it governs, or at least to the locking arrangement by which the switch is held in position after it has been thrown.

The use of this signal nowadays is confined to very unimportant tracks where cars are placed to be unloaded, and even then it is better practice to use a dwarf signal of the semaphore type.

We now come to the use of three-position signals for route signaling. The three-position signal is an evolution and was suggested by motives of economy. In England, where semaphore signals were first used for railroad purposes, the two-position signal is the universal type. There semaphore signals are so numerous that it became frequently advisable to place the distant signal for one home signal on the same mast with the home signal next in front of it, as shown in Fig. 6.

Fig. 6.

This condition exists more frequently with block signals than with route signals, but as we have not yet arrived at that part of the subject we will as-

sume that this condition applies to route signals pure and simple.

English practice at first ruled in this country, but later some American signal engineers suggested an arrangement by which one blade could be made to do double duty and act both as a home and distant signal. This was accomplished by having the blade horizontal as at a, Fig. 7, mean

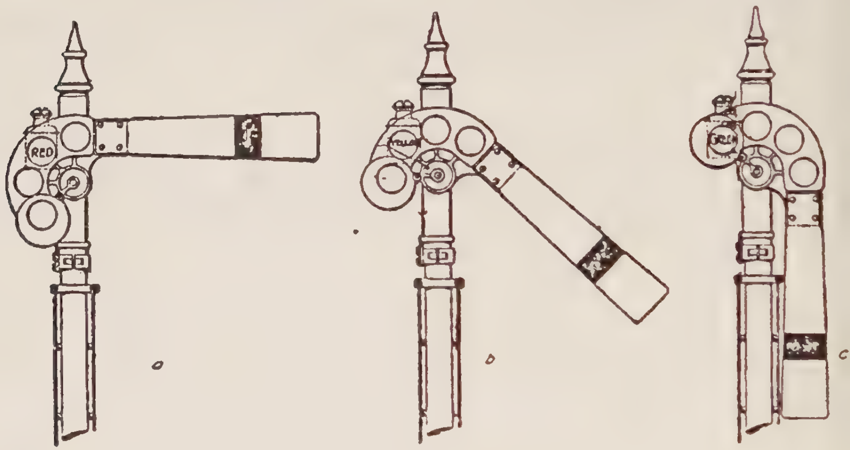


Fig. 7.

stop, inclined downward at an angle of 45° as at b, mean proceed cautiously, and vertically downward as at c mean proceed without limitation. This effected a saving of a blade with its attachments and lamp for each mast from which a home and distant signal had been displayed. For route signaling proper, such as we are now discussing, the need for such an arrangement does not often occur, yet there are times when it is very convenient to display a distant signal for a home signal further away from the same mast as a home signal.

A typical case of this is shown in Fig. 8, the upper line showing how it would be done in a two-

position system, and the lower line showing the same with a three-position system.

As stated earlier, the most recent suggestion is to give the indication in the upper quadrant instead of the lower one. So far this is confined to a three position system, although there is no reason that it could not be applied equally as well to a two-position system.

Undoubtedly the use of three-position signals has grown in favor very rapidly during the past five years, yet there are still many firm supporters of the two-position system, who advance arguments in support thereof well worth consideration. It would hardly be desirable to go further into this phase of

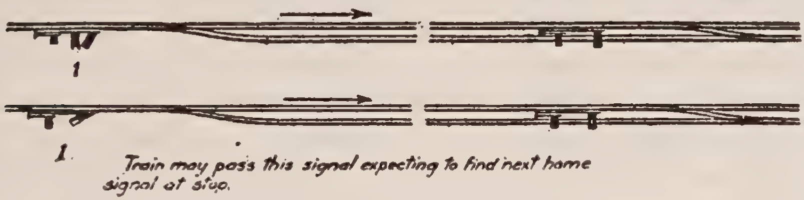


Fig. 8.

the subject at the present time, but before closing this work I shall endeavor to lay before the reader both sides of the question and allow him to form his own opinions.

The proper placing of signals is a very important question and one which should be given the most careful attention.

Where single masts are used they should, whenever possible to do so, be placed on the right-hand side of the track they govern, and the blade should always extend from the right-hand side of the mast, except on two or more track railroads, where trains, as is the custom in England, habitually pass each other to the left, when the mast is placed on the left-hand side of the track it governs, with the blade extending from the right of the mast.

Happily for the uniformity of American signal practice there are not many of our railroads which run "left-handed," and one at least of the most important of these proposes to abandon this custom in the near future, an example which will no doubt soon be followed by others.

The distinction between the right and left hand of a track is made as follows:

The direction of traffic on a double track line is of course established. If a person stands with his back towards an approaching train and facing in the direction the train is moving the right side of the track will be that on his right hand, just as the starboard side of a ship is the right side to a person facing the bow.

On double track, too, this nomenclature, just as on shipboard, never changes. For example, on a double track right-hand railroad running due east and west the south side is always the right-hand side of the east-bound track, and the north side the right-hand side of the west-bound track, no matter in which direction an observer is facing.

On a single track railroad this rule does not hold good. Taking a line running due east and west, for example. The south side is the right-hand side for an east-bound train, and vice versa for a west-bound train.

It might really be more accurate to say that a signal should be placed to the right of the train it governs, but the American Railway Association in its standard rules has used the expression first given, i. e., that a signal should be placed to the right of the track it governs, and this wording has been taken up by several state railway commissions in their published rules, so that it has become almost a standard expression, and its meaning is perfectly clear to most railroad men.

There are cases where some permanent obstruction to the view renders it inadvisable to place the signal to the right of the track it governs, and my experience has led me to believe that no very great harm is done when it is not so placed. It is far more important to have a signal conspicuously placed than to have it placed correctly from a theoretical standpoint, without reference to whether it can be seen from an approaching train or not.

As a matter of fact, no man is allowed to run an engine on any railroad who is not familiar with the road, unless he is accompanied by a pilot who is familiar with it, and knows what signals he is to look out for. However, as a general thing it is much better to place signals uniformly wherever they can be seen if so placed by a person whose actions they are intended to govern.

In some cases, as that of a three or four track line, it is impossible to place a signal governing the inside track between it and the outside track. In such cases a so-called bracket pole is used, or sometimes a signal bridge. See Fig. 9.

Where the bracket pole is used the term mast

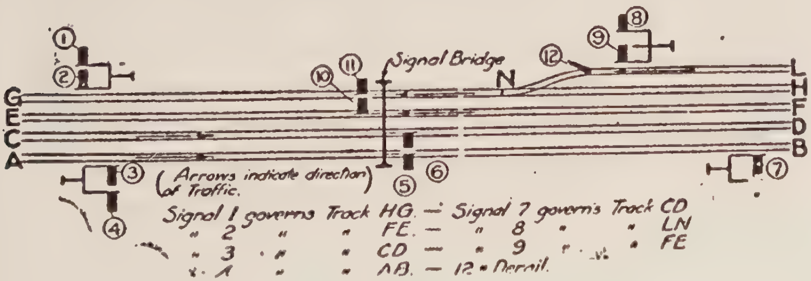


Fig. 9.

is applied to the small pole above the bracket. This is also frequently called a doll pole. The signals displayed from the inside mast govern the inside track and those from the outside mast govern the

outside track. Where a signal bridge is used the signals attached to masts similar to those used on the bracket pole are placed either directly over the right-hand rail of the track they govern or over the center of that track. The latter will be found to be the better practice, because in case of signals for one direction being displayed over one track and for the opposite direction on the next track to its right, as will be the case with the two middle tracks of a four-track line, where the tracks are used alternately for movements in either direction—that is, taking an east and west line, if the north track is used for west bound, the second from the north for east bound, the third from the north for west bound and the south track for east bound, the blades of the signals will overlap each other if the masts are placed over the right-hand rail. Fig. 9 shows a four-track line signaled by both bracket poles and a signal bridge, using the conventional sign for the bridge.

Sometimes the signal cannot be placed to the right of the track it governs, but can be placed one track further to the right, yet this second track may require no signal. A bracket pole is then frequently used with a signal displayed from the inside mast and no signal on the outside mast, as shown at No. 7, Fig. 9, where the signal governs trains running on track C D and no signal governing trains on track A B is displayed from the same bracket pole.

Another case is illustrated with signals 8 and 9 in the same figure. Here there are three masts on the bracket pole, from the two outside ones of which, only, signals are displayed. This means that the outside signal governs the outside track; the next track has no signal, and the inside signal governs the third track.

The use of bracket poles with more than two masts should be avoided, and where there are more than four tracks parallel to each other on any of which fixed signals are to be displayed, it will generally be found that the use of signal bridges is more satisfactory than the use of bracket poles.

Where route signals are placed on bracket poles or bridges some signal engineers who follow out the practice of signaling low speed routes with dwarf signals, in the case of single poles, will allow the use of lower high arms. In my opinion this is not good practice, and a dwarf signal on the ground had better be used.

In the foregoing I have endeavored to lay before the reader as succinctly as possible what is known as the language of fixed signals.

The intelligence conveyed by a fixed signal such as a distant signal displayed at caution, meaning proceed prepared to stop, at the home signal half a mile further on, or the lower blade on a home route signal mast displayed at clear, meaning proceed by the inferior route, is known as the *indication* of the signal.

The appearance of the signal itself is known as its aspect.

For instance: In a two-position signal system we would say that the aspect of the caution indication is a green blade with a forked end displayed in the horizontal position, while the aspect of the indication for "proceed by the inferior route" at a junction is a red blade displayed in the inclined position beneath a red blade displayed in the horizontal position.

So far I have said very little regarding night indications, and only mention that subject now to show the reader that I have not overlooked it. I believe it is better to become thoroughly familiar

with the day indications before taking up the subject of night indications, and shall, therefore, postpone what I have to say on that head to some later chapter.

As the next branch of our subject we shall come to is that of interlocking by which it is rendered impossible for the person handling the signals and switches at points where routes are changed to display anything but the proper signals for a given route, I want to say a word before closing this chapter about derailing switches, commonly called derails.

These are contrivances placed in the track by which an engine or train which has overrun a stop signal will be thrown from the track. There are many types of derails which will be taken up in detail in the proper place. They are generally shown on track plans as at No. 12, Fig. 9, and for the present we will so show them on all figures until we have taken up the various types in detail.

We shall now take up the subject of interlocking.

CHAPTER III.

INTERLOCKING—MECHANICAL.

The definition of interlocking given by the American Railway Association is "an arrangement of switch, lock and signal appliances, so interconnected that their movements must succeed each other in a predetermined order."

It is quite possible to fulfill the requirements of the definition by apparatus wherein the mechanisms by which the switches, signals, etc., are moved are separated by considerable distances. Wherever this is done these mechanisms must be operated by different persons or the person who does operate them must move from place to place, entailing a considerable loss of time and needless expenditure of labor. It is, therefore, much more convenient to assemble all the operating machinery in one place and to transmit the power by which the switches and signals are to be moved from this central location.

In the earlier interlocking arrangements the only power used was manual, and instead of throwing the switches by the usual revolving switch stands, it was found more convenient to use levers.

For the sake of uniformity similar levers were used for the signals and such other devices as it was found expedient to have operated in connection therewith. These levers were and are placed in a frame side by side. When this was done it was found much more convenient and economical to interlock

the levers with each other than to interlock the switches and signals out on the ground.

This combination of levers and interlocking makes the interlocking machine.

Where manual power is used to move the switches, signals, etc., the levers of the interlocking machine perform two offices—that of actually transmitting the force exerted by the person handling them to the device to be moved, and also that of locking and unlocking such other levers as the particular combination then to be used requires.

Where some other form of power than muscular strength is used the levers in the machine open and close electric circuits or valves through which the power used is transmitted to the operating devices, and also operate the locking in the same way as in a manual machine.

There are several types of interlocking machines, differing from each other in their form of construction, but the following rules are general to all:

(1) The front of the machine is that side on which the person operating it stands, when doing so.

(2) The levers are numbered from the left of a person standing facing the front of the machine to his right, number one lever being always at his left hand, and the highest numbered lever in that particular machine at his right.

Locking may be either vertical or horizontal.

One type which is most generally horizontal accomplishes its purpose in the folowing manner:

The lever is attached by a crank to a rectangular bar of steel in such a way that the first movement of the lever, or of any part of it, slides this bar horizontally in a vertical plane parallel to the row of levers in the machine, and from right to left. Riveted to the upper side of this bar are steel dogs

with wedge shaped ends. At right angles to this bar and across the top of it are laid other bars in which slots or notches are cut opposite to or nearly opposite to such of the dogs as come near this cross bar.

The first mentioned bars are called locking bars, and those which lie across them are called cross locks; and to simplify the explanation they will be so called hereafter.

Both the locking bars and the cross locks are held in place by guides so that they are free to move only longitudinally.

If the notch in a cross lock is so shaped that the dog on the locking bar cannot pass through it when the cross lock is in its normal position, but by virtue of its wedge shape can slide the cross lock along longitudinally into a position in which the notch comes directly opposite the dog so that it (the dog) can pass through the cross lock, the locking bar is then free to make its travel. If, however, a dog attached to another locking bar is already passed through the cross lock so that the cross lock cannot move longitudinally (the guides preventing its movement in any other direction), then the dog on the first locking bar cannot pass through it, and the first bar cannot move, i. e., is locked by the second bar.

Fig. 10 will serve to illustrate this more clearly. In it are shown a front view, a side view and a plan of three short locking bars, numbered 1, 2 and 3, each with a dog on it, and a piece of cross lock notched for each of these dogs.

The shape of the notches in the cross lock is shown by the dotted lines, and the shape of such part of the dogs as is entered in the notches of the cross lock is shown also by dotted lines.

Reference to the plan will show that in the posi-

tion given locking bar 2 is free to move in the direction of its arrow, because the notch in the cross-lock is directly opposite its dog.

The dog on No. 3 locking bar, it will be noticed, passes completely through the cross-lock, thereby preventing the movement of the cross-lock in either direction indicated by the double-headed arrow, and the guides (which are omitted from the drawing, both from the cross-locks and the locking bars, for the sake of clearness) prevent its moving sideways.

No. 1 locking bar cannot be moved in the direction of its arrow, because the center line of its dog and the center line of the notch in the cross-lock,

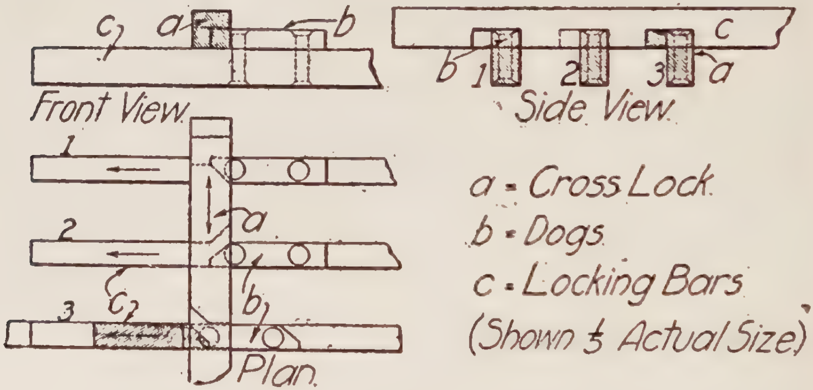


Fig. 10.

which notch is exactly large enough for the dog to pass through, are in two different vertical planes. No. 1 locking bar, therefore, is locked by No. 3.

Now if No. 3 is moved in the direction of its arrow until its dog assumes the position indicated by the shaded lines, No. 1 will be free to move in the direction of its arrow, because No. 3's dog will have moved free of engagement with the cross-lock. Nevertheless, when No. 1 does move, its dog will shove the cross-lock down against the wedge end of

No. 3's dog, and at the same time will move the center line of the notches opposite No. 2's and No. 3's dogs into vertical planes not coincident with the vertical planes in which the center lines of No. 2's and 3's dogs move.

This movement of No. 1 locking bar, therefore, it will readily be seen, locks No. 2 bar from moving in the direction of its arrow, and No. 3 bar from moving back into its original position.

As a matter of fact the position in which the locking bars are habitually kept, known as their *normal* position, is as far to the right as they are permitted to travel, and as this figure presupposes that all bars are in their normal position at the start, this last movement of No. 1 locking bar locks No. 2 locking bar in its *normal* position.

The travel of the locking bars from right to left is limited by the stroke of the cranks by which they are connected with the lever, which is 1¾ inches, and when they have traveled as far to the left as it is possible for them to go, they are said to be in their *reversed* position.

For the sake of brevity the word position is usually omitted and the condition existing in the last described position of the locking shown in the figure would be explained by saying that No. 1 locking bar *reversed* locks No. 2 locking bar *normal* and No. 3 locking bar *reversed*.

The foregoing gives a general outline of the principles on which the locking of the improved Saxby and Farmer interlocking machine is founded. This machine is by far the most generally used in the United States, where a machine with horizontal locking is required for use with a man-power interlocking arrangement. The same principle of locking, too, is used on some of the machines which

serve to transmit some other power than a man's to throw the switches, signals, etc.

Fig. 11 shows a sectional view and Fig. 12 a front

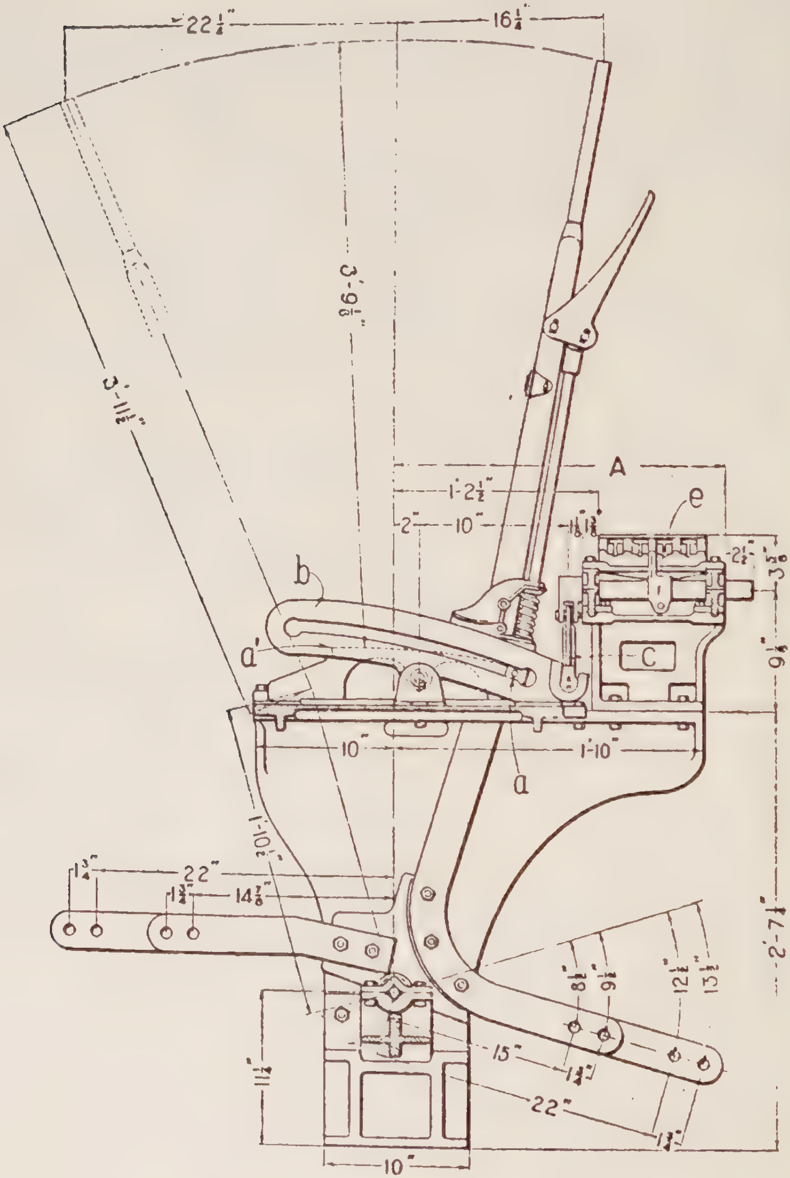


Fig. 11.

view of an 8-lever improved Saxby and Farmer interlocking machine. By reference to the side view the reader will see that the lever is held in its place at either end of its stroke by a latch which is pressed downward by a strong coil spring, so as to engage notches shown as a a^1 in the ends of two cast iron guides between which the lever passes in its stroke. The upper edges of these guides are curved and form an arc of a circle with

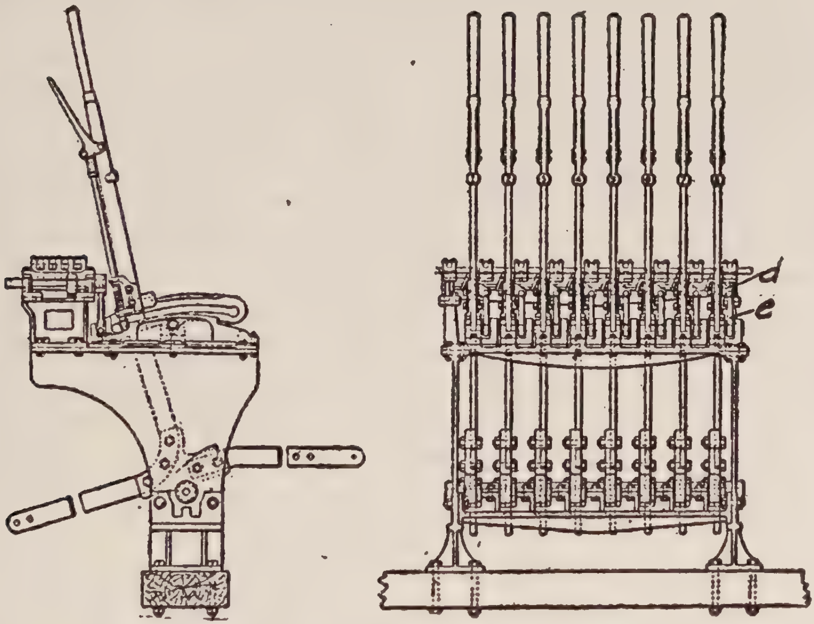


Fig. 12.

the pivot of the lever as its center. The lever can only be moved in either direction by the operator pressing in on the latch handle with force enough to overcome the resistance of the spring, or by another movement which we will shortly mention. If after the latch is moved in this way the lever is also moved, the latch may again be released, and slides along the top of the guide until the lever reaches the end of its stroke, when it will be

pushed down by the spring into the notch at that end, thereby holding the lever firmly in place. The guides which are usually cast together in one piece are called the quadrant—a misnomer, by the way, as the curved side does not form the fourth part of the circle which the bottom side of the latch would describe if the lever was revolved completely around on its pivot.

The latch has a projection from one side which engages a slot in what is known as the rocker, which is placed alongside of the lever in a plane parallel to the plane in which it, the lever, moves. It is shown as b in the figure. This rocker, it will be noticed, is pivoted in the middle, but is free to move vertically up and down at the ends. When the latch is down in the notch a, that end of the rocker is pressed down, and the other end is raised up. In this position, although the circle of which the slot in the rocker is an arc, is of virtually the same radius as the circle of which the upper edge of the quadrant is also an arc, these circles are not concentric, but when the latch is raised that end of the rocker also comes up, depressing its other end and bringing it into a position where its circle is concentric with the circle whose center is the pivot of the lever. As the lever is moved, therefore, the projection from the latch slides through the curved slot of the rocker, just as the bottom face of the latch slides along the upper side of the quadrant. This arrangement plays a very important part in the improved Saxby and Farmer machine, as will shortly be seen.

As a matter of fact, persons used to handling these machines frequently raise the latch when the levers are in the position shown in the figure by pressing down on the front of the rocker, with the foot, which raises the latch and closes the latch

handle in against the lever just as if the hand was closed on it, but this in no way affects the working of the mechanism which we are explaining.

It should here be fully understood that the operator or leverman, as he is generally called, always stands on the same side of the machine as notch a^1 in the quadrant—that is, so that when the lever is in the same position as shown in the figure it leans away from him, and in order to move it he must pull it towards him. As before stated, the side on which he stands is the front of the machine, and the front of all parts of the machine is towards that side.

At the back end of the rocker, it will be noticed, is a connection known as the universal link, shown as c in the figure. One end of this universal link is attached to the rocker by a pin, and it moves up or down with the back end of the rocker.

The other end is attached to a short crank (better seen in the front view of the machine) and marked d. This crank is rigidly attached to a square shaft with turned journals resting in bearings behind the levers, and with its axis parallel to the plane of the lever's stroke.

It will now be readily seen that when the latch handle is closed in to the lever, and the latch raised, bringing with it one end or the other of the rocker, the universal link is either raised or lowered according to which end of its stroke the lever is in, and a rotary motion is imparted to the locking shaft.

The locking bars already described lie between their guides—called brackets—over the locking shafts. By a specially designed crank called the driving piece one or more of them is attached to each locking shaft. As the locking shaft revolves (to the left, if the lever is at the back of its stroke,

and to the right if the lever is at the front of its stroke, when the latch is raised), it slides the locking bar or bars to which it is attached to the left or right with it, thereby moving such dogs as are riveted thereto and performing such locking as is required of it. If, of course, the cross-locks are so held by dogs attached to other locking bars that one or more dogs attached to the particular locking bar we are discussing cannot move, the locking bar, as already seen, is also held fast, in turn holding the locking shaft, the universal link, the rocker, and lastly the latch. Until the latch can be raised the lever cannot be moved.

This is known as preliminary or latch locking, and is one of the most ingenious and useful refinements known to signal engineers. Its use insures that a lever has not only made its full stroke, but is *securely latched* in its final position before any conflicting lever is unlocked, and also that the leverman cannot throw his full strength against the lever when locked. Where no preliminary locking is used, very powerful men have been known to force levers over by tearing the locking loose when they have thrown their full weight and strength against them.

No American railroad will accept an interlocking machine by which switches or derails are operated any distance away, which does not have this feature, and State authorities whose duty it is to inspect such devices, rigidly enforce its use.

The assembly of locking shafts, locking bars, cross locks, brackets and supports for same, is known as the locking bed. The supports on either side of the machine, as shown in the figure, are the legs; the cross piece on which the levers are pivoted is the bottom rail; the plate which connects the legs together at the top is the top plate.

For a more detailed description of each of these various pieces the reader is advised to secure a copy of the catalogue of one of the large signal companies.

Machines are made in four and eight lever sections. A 20-lever machine, for instance, would be built up of two 8-lever and one 4-lever sections. It would have four legs, two eight-way, and one four-way top plates, two eight-way, and one four-way bottom rails, and a locking bed long enough and wide enough for a 20-lever machine.

Vertical locking is usually of a different design from the Saxby and Farmer locking first described, although one signal company has recently put a

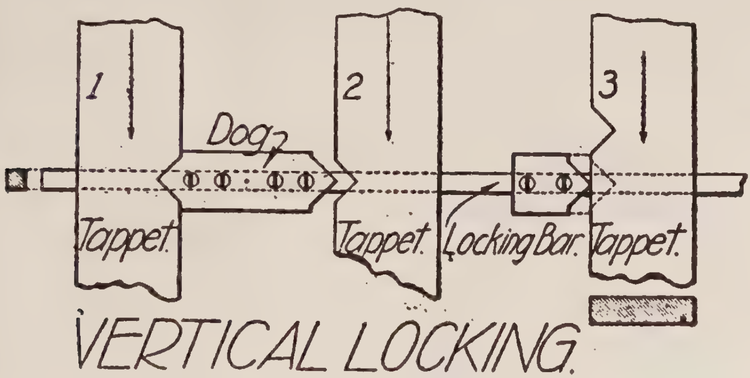


Fig. 13.

Saxby and Farmer machine on the market, so arranged that the locking may be placed vertically.

In the most frequently used types of vertical locking, the movement of the lever latch slides a so-called tappet vertically up and down. This tappet has V-shaped notches cut in its edges which engage flat, pointed dogs fastened to locking bars to which other dogs may be fastened, which in turn engage the tappets of other levers, thus performing the locking.

Fig. 13 shows parts of three tappets, with the

necessary dogs to perform the same locking as already described for the Saxby and Farmer machine, viz.: No. 1 reversed locks, No. 2 normal; and No. 3 reversed.

Fig. 14 shows a sectional side view and a front view of one style of interlocking machine with vertical locking. The rocker, it will be noticed, is below the quadrant, and is connected to the tappet

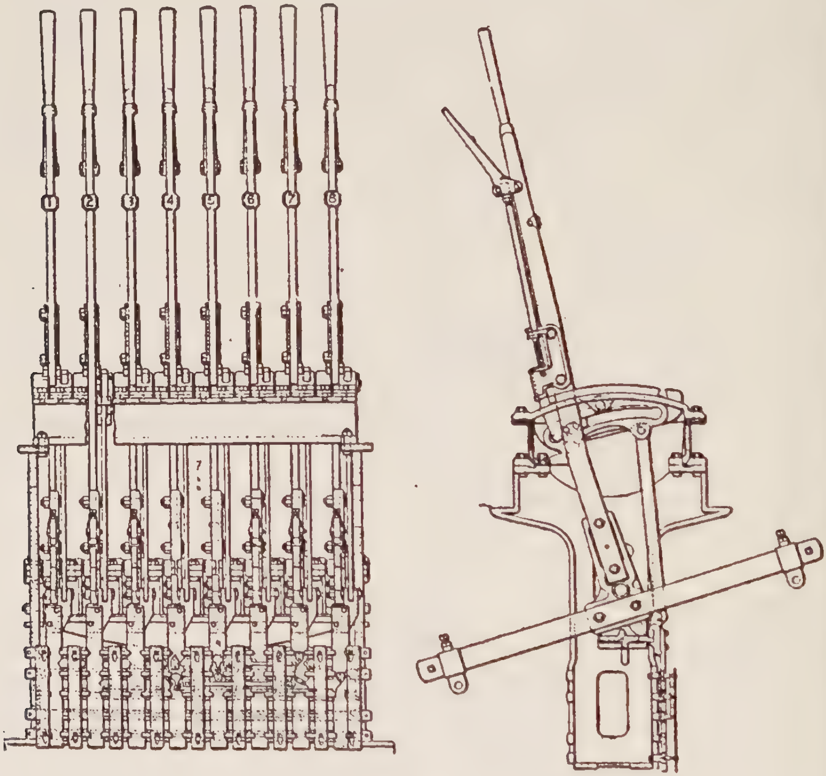


Fig. 14.

by a flat bar called the connecting link. When the latch is raised with the lever thrown backward as shown in the figure, the front end of the rocker is depressed, and through this connecting link slides the tappet downwards; the reverse being true when

the latch is raised with the lever in the front position.

There is a greater variety of interlocking machines with vertical locking than with horizontal locking, as the Johnson, the National, the Standard, and the Style A, but they differ only in details of construction, and anyone who understands the interlocking of one of them will readily understand it of all.

There is another type of interlocking machine known as the Stevens, the locking of which is similar to that of the vertical type already described, except that it lies in a horizontal or curved locking bed. The tappets are attached directly to the lever, and there is no preliminary locking in this type of machine. It should, therefore, not be used for work where switches and derails are to be thrown at any distance from the machine.

There is some difference of opinion as to the merits of the horizontal and vertical locking among signal engineers, but I believe I am safe in saying that the improved Saxby and Farmer type of horizontal locking is favored by the majority. There are some situations where the width of the room in which the interlocking machine is to be placed is limited where it is very convenient to use vertical locking.

Interlocking machines by which the muscular power of the operator is used to throw the switches, signals, etc, are known amongst Signal Engineers as *mechanical* interlocking machines. Where compressed air or electricity is used to throw the switches, signals, etc., and the strength of the operator is only required to move the locking in the machine, and to open and close the valves or contacts by which the power is turned on to the oper-

ating device, the machines are called *power* interlocking machines.

This nomenclature is probably not the best, but it has been accepted and is now so thoroughly a part of the tecnique of the profession that I shall use these names hereafter throughout this work.

The following rule is general to all mechanical interlocking machines:

When normal the levers are always in the position shown in the two foregoing cuts; that is, leaning away from the front of the machine.

In all interlocking machines one lever when reversed may lock another, in three ways:

(1) Normal.
(2) Reversed.
(3) Normal and reversed.

We have seen how the first two may be accomplished. Fig. 15 shows the method of accomp-

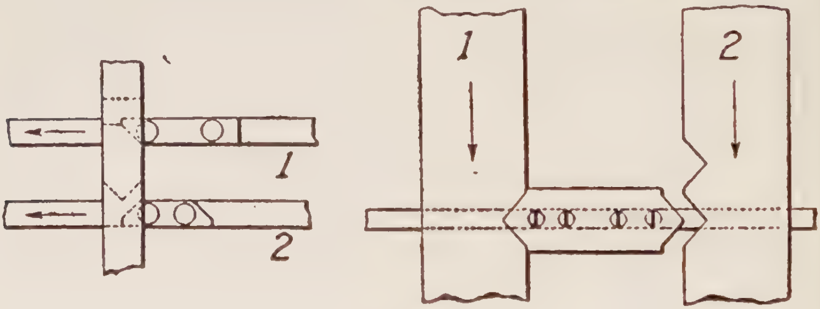


Fig. 15.

lishing the third by either the Saxby and Farmer, or the vertical (flat) locking. In either case locking bar or tappet No. 1 when reversed locks locking bar or tappet No. 2, both normal and reversed.

There are two other points which should be thoroughly grasped, viz:

(1) That when one lever reversed through either a locking bar or tappet locks another lever normal

the opposite condition, i. e., that the second lever when reversed will always lock the first lever normal, is true.

(2) That, when one lever reversed locks another one reversed, both levers being normal, the second one always has the first one locked normal and must be reversed to unlock it. This will be seen at once by reference to Figs. 10 and 13.

Besides the simple locking already described, special locking is sometimes required. That is, it may be necessary to have lever No. 1 reversed, for instance, lock lever No. 2 normal when lever No. 3 is reversed, but not when lever No. 3 is normal.

Before describing the manner of accomplishing this with the Improved Saxby and Farmer locking, I wish to explain that for the purpose of clearness of illustration in the Saxby and Farmer locking shown in Fig. 10, I have shown the locking bars spaced some little distance apart. In reality these bars are put into the locking bed in pairs, side by side, with a space of ⅝ in. between each pair. See Fig. 16, which shows eight locking bars in section,

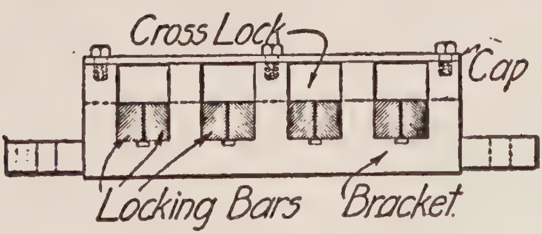


Fig. 16.

with side view of a cross lock above them as they would appear in actual practice. I may also state here that although the locking bars are numbered from the front to the back of the locking bed in consecutive order, as will be explained more fully when we get to the designing of locking for specific cases, the numbers of the locking bars have no

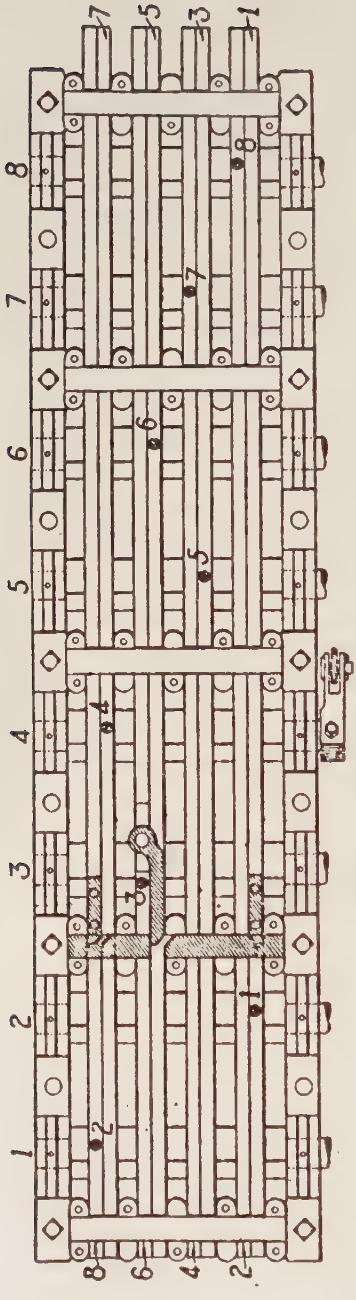


Fig. 17.

reference to the number of levers by which they are driven. Number one lever may drive a locking bar of any number or even two or more bars, and hereafter I shall refer to the lever numbers only and omit reference to the numbers of the locking bars.

Fig. 17 is a plan view of the eight locking bars in Fig. 16 with the caps of the brackets removed for clearness of illustration.

On each locking bar the black dot (used for clearness), denotes its driving piece, or driver, as it is commonly called, the number indicating the lever to the locking shaft of which the driver is connected. A small circle, it may as well be noted here, is the conventional manner of showing the driver, used on the plan views of locking beds drawn up and put into the hands of the mechanics who build interlocking machines, or who make alterations in the locking in the field after machines have once been installed. These plans are known as dog sheets, and will be more fully described in their proper place.

In addition to the regular dogs, it will be noticed that a long crooked dog is attached to the bar driven by lever No. 3, its end, however resting on the bar driven by lever No. 6. It should also be noted that the cross lock opposite the point of this crooked dog is divided completely in two, so that the two portions of it can move independently of each other.

This crooked dog is called by the manufacturers a tappet, or swing dog. By signal men it is often called a special dog, and sometimes a "when" dog. As tappet might be confused by a beginner with the tappet of the flat locking, and as other special dogs may be mentioned, I shall call these tappets hereafter in this description "when dogs," or "whens," a name which is peculiarly significant, as will soon be seen.

This "when" is not riveted to the locking bar, but is held loosely by a turned pin forming part of a trunnion which is riveted to the bar. This arrangement allows the "when" to swing in the same direction as the cross lock will be moved by the dog on the locking bar driven by lever No. 1. With lever No. 3 normal (all levers are assumed to be normal in the figure), lever No. 1 can be reversed and its dog will slide the portion of the cross lock which it engages in the direction of the when dog, so as to close up the gap between it and the other portion of the cross lock, but this latter portion will not be moved.

If, however, lever No. 3 is first reversed, the "when dog" will slide into the gap between the two portions of the cross lock, filling this gap up. Now if lever No. 1 is reversed it will push the lower portion of the cross lock in the direction of the arrow as before, but as the gap between the two portions of the cross lock is now filled in by the

"when," which, being, pivoted on its trunnion swings away from the pressure of the lower portion of the cross lock, transmitting the movement of the lower portion to the upper portion, the dog on the locking bar driven by lever No. 1 will lock the dog on the locking bar driven by No. 2, normal, just as if the cross lock was one continuous piece. The condition already alluded to when we first commenced the consideration of special locking is, therefore, fulfilled. That is, that lever No. 1 reversed, locks lever No. 2, normal, *when* lever No. 3 is reversed, but *not* when lever No. 3 is normal. The significance of the term "when dog" will now be seen.

There is another point which I want to call to the readers' attention before going on to describe the method of accomplishing special locking where tappet bars are used. Where a dog drives a cross lock in such a way that all the locking is accomplished on one side or the other of this dog, it is not necessary to notch the cross lock. It may be divided at the locking bar to which the driving dog is attached, and that portion only which is on the side of the dog where the locking is to be accomplished will be moved by it. The remainder of the cross lock may be driven by a dog on some other bar. This renders it possible to economize in the use of cross locks. As a rule there is one locking bracket with cross locks in it for each two levers in the machine, although the locking beds are so arranged that intermediate brackets may be put in, thus making a bracket for each lever. The necessity for this does not often arise, however.

Fig. 18 illustrates the various forms of dogs used with improved Saxby and Farmer locking. When we come to the discussion of dog sheets, the reasons for the different shapes will become apparent.

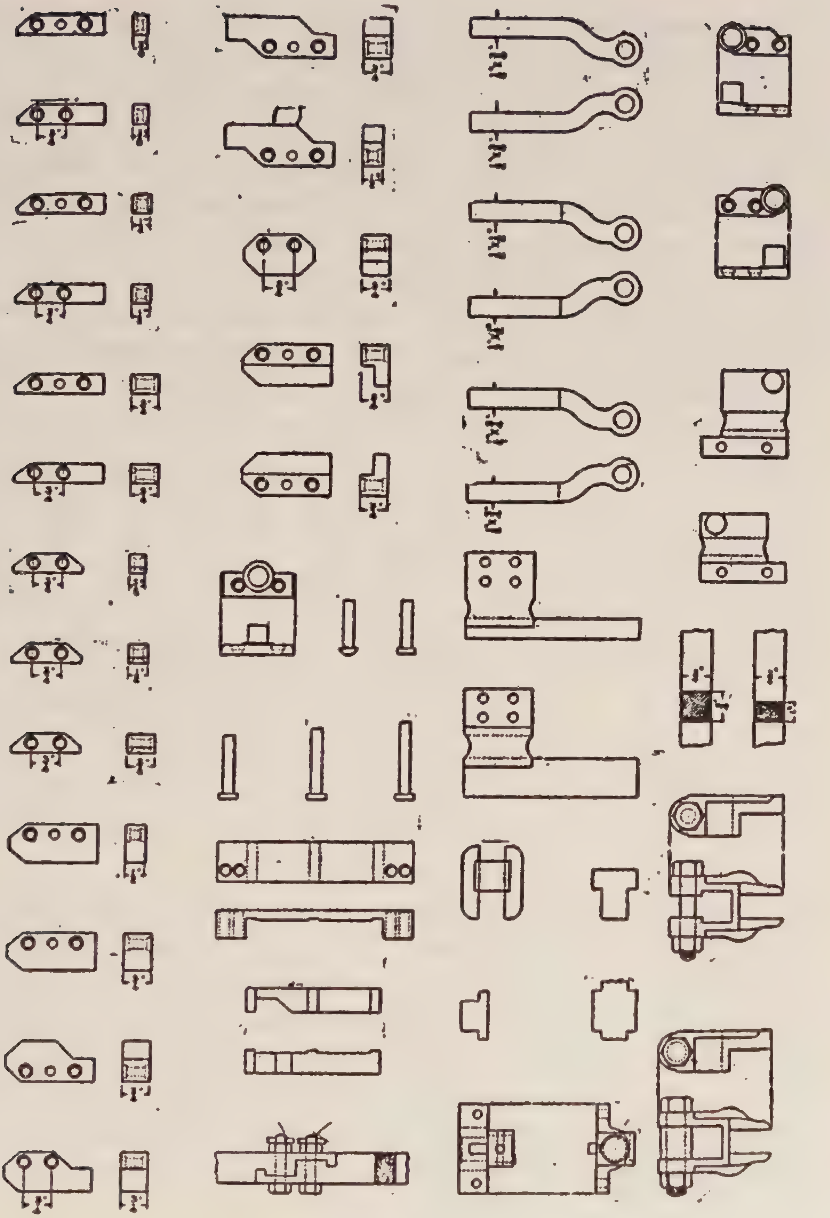


Fig. 18.

In machines with vertical locking beds, where tappets are used, the special locking is accomplished on the general principle of having a piece attached

to the tappet of the controlling lever, so arranged that it can move sideways. Two dogs which do not move in the same vertical plane as the tappets, but in a vertical plane parallel thereto and immediately in front of, or behind the tappets, according as the locking bed is on the front or back side of the machine, are placed on either side of this movable piece. If the controlling lever acts in its normal position, then this movable piece is between these dogs, so that a movement of the dog on one side in the direction of the other dog will be transmitted to the second dog through the movable piece. This

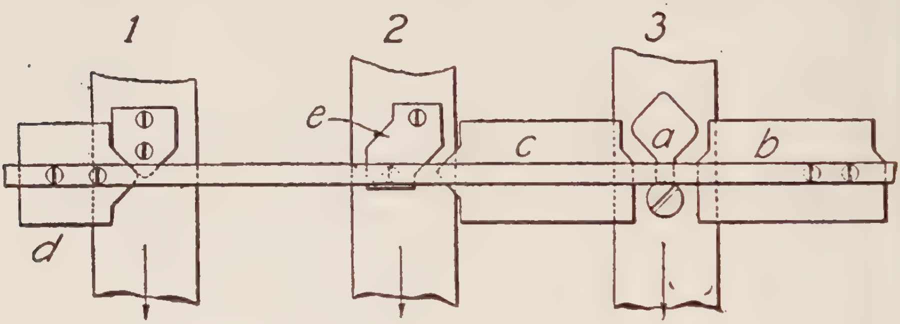


Fig. 19.

second dog either itself locks the tappet of the lever to be locked, or through a locking bar moves another dog, which does so. If the controlling lever is reversed, the lever which drives the dog on one side of the tappet, will only drive it into the vacant space left by the movable piece which has been removed by the reversing of the controlling lever. The opposite of course is true, if the controlling lever acts when reversed.

The arrangement of the details of this controlling piece vary somewhat in different makes of machines, but the general principle is the same.

Fig. 19 shows portions of three tappet bars, with

the necessary dogs to do the same locking as is described for the Saxby and Farmer machine, viz.: Lever No. 1 reversed, locks lever No. 2 normal, when lever No. 3 is reversed. In this type of locking, which is in common use, a swing dog fastened to the tappet of the controlling lever serves to transmit the movement of another dog moving in the same plane as the swing dog to a third, also in the same plane as the swing dog, which in turn either drives another dog in the same plane as the tappets, or itself locks a tappet by having its other end bent so as to move in its plane, or engages a dog rigidly fastened to the tappet so as to act in the same way that a notch in its edge would act.

In the figure, driving dog d, which is moved to the left, when lever No. 1 is reversed, transmits its motion to dog b, which slides along the face of No. 3's tappet. If No. 3 is reversed, dog b strikes the projecting side of swing dog a and moves it towards the left. The projecting end of a on the other side in turn moves c to the left. The end of c farthest from a engages the dog e rigidly fastened to tappet No. 2, thereby locking lever of that number normal.

If lever No. 3 is normal, as is the case in the figure, dog b passes into the recess in the side of a and does not move a at all.

The special locking in other types of machines is so similar to what has been described that I shall not take space to go into it more fully. If the reader will examine any Johnson or National machine, he will be able in a moment, from the above description, to understand the special locking of these machines.

CHAPTER IV.

INTERLOCKING-POWER.

The interlocking of the levers in power interlocking machines is accomplished as described for mechanical machines, except that the feature of latch locking, as applied to mechanical machines, is sometimes, in fact more generally, omitted, and its place supplied by what is known as the *indication.*

Before I go into the subject of indications, I shall state a few elementary principles in the application of electricity to the performance of mechanical work.

I shall state these simply as facts, and if the reader wishes to verify them, or to inform himself as to the reasons for their existence, he should procure an elementary treatise on electricity and magnetism, such as is given in the ordinary works on Natural Philosophy used in high schools.

(1) If two plates of different substances which form an electric couple, are submerged in a solution of acid, without touching each other after they are submerged, and are then connected together outside of the acid by an iron or a copper wire, an electric current will flow through this wire.

(2) When designed especially for the purpose of generating electricity the electric couple, the acid (called the electrolyte) and the vessel or jar in which they are held, taken together, is called a cell.

(3) A collection of one or more cells coupled together, is called a battery.

(4) The electric current flows through the elec-

trolyte from one plate of the electric couple to the other, through that plate, along the connecting wire and back to the first plate. The connections of the wire to the plates are called the poles of the battery.

(5) If the wire is broken at any time the current ceases to flow. An arrangement can be made by which the wire may be temporarily broken or temporarily connected so that the flow of the current may be shut off or continued at will. One of the most familiar instances of this is an electric door bell. We push on the button, thereby connecting the two ends of a wire which passes through the bell and connects the two poles of the battery, and the bell rings because we have completed the circuit, as it is called, and the current flows through the operating mechanism of the bell. We let go of the button, it is pushed back by a spring and breaks the wire (opens the circuit), the current ceases to flow and the bell stops ringing.

(6) A magnet is a piece of stone or metal which has the power of attracting towards it iron, and to a minor degree some other metals.

(7) A natural magnet is usually a stone which has this power. An artificial magnet is a piece of iron or steel which has been given this power by some artificial means.

(8) Some substances, like rubber or silk, will not carry an electric current in appreciable quantities. These are called insulating substances. An iron or copper wire covered with rubber or silk is said to be insulated.

(9) If an insulated wire through which an electric current is passing is wound around a piece of steel or iron (see Fig. 20), the steel or iron becomes a magnet. In the case of the steel, after it has once been converted into a magnet in this way and the

electric current is cut off, it will remain a magnet, but in the case of pure iron, it ceases to be a magnet almost instantly after the flow of the current stops.

(10) Within certain limits, the more turns of wire made around the steel or iron, the stronger the magnet will become, for the same amount of current. By winding a great many feet of wire around a round soft iron bar, a few inches long, called the core, and leaving the two ends of the wire exposed so that they can be connected by other wires to the poles of an electric battery, we have what is known as an electro-magnet. A piece

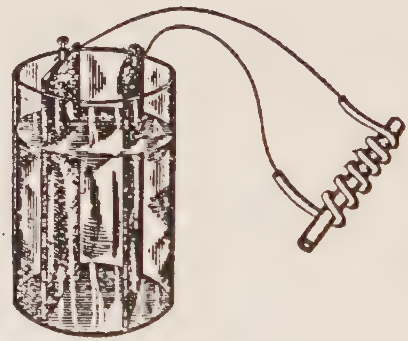


Fig. 20.

of iron is placed near one end of the core and is so held by guides that it cannot get so far away from the end of the core that the attraction of the core when it is magnetized is insufficient to lift this piece of iron. Every time, therefore, that an electric current is sent through this coil of wire (called the magnet coil) the core becomes a magnet and lifts up the other piece of iron, which is called the armature, holding it up as long as the core is magnetized. When the electric current is cut off, the core (being soft iron) ceases to be a magnet, and if the armature is at the bottom side of the

core, it will fall away therefrom by gravity, as far as its guides will allow it. In this way an electric current which cannot be seen or heard can be made to perform mechanical work.

The electro-magnet appears everywhere in signal engineering, and its principle should be thoroughly understood.

The power machines in most general use today are the Union Switch and Signal Company's electro-pneumatic, the Union Switch and Signal Company's all electric, and the General Railway Signal Company's all electric. Other good machines are to be had, but so far as the interlocking of the levers is concerned, it will be enough to call the reader's attention to a few minor details in which the interlocking of those machines just mentioned differs from that of mechanical machines.

In the two former, the locking is of the Improved Saxby and Farmer type. The so-called levers are in reality cranks, and are attached directly to the locking shafts. The driver, instead of being a specially designed crank, as is the case in the mechanical machine, is a small rack and pinion, the pinion being attached to the locking shaft, and the rack being formed by cutting teeth for a short distance in the bottom of the locking bar.

The arrangement of dogs and cross locks is much the same in the power as in the mechanical machine.

Certain levers drive the bars toward the right only, and other levers are normal in their mid stroke, and drive their locking bars both to the right and left. This to some extent modifies the shape of the dogs, and the manner in which they are fastened to the locking bars, but the reasons for these modifications are so apparent to anyone who understands the Improved Saxby and Farmer

interlocking as applied to mechanical machines, that a further discussion of this side of the subject would be unprofitable here.

The locking in power machines, as it cannot be subjected to very rough handling, is made one-half the size of that in mechanical machines.

The levers of a power interlocking machine require the exercise of very little strength on the part of the leverman, as they are not connected directly by mechanical means to the switches, signals, etc., which they operate, and the leverman can not tell by the "feel" of the levers, as is the case with the mechanical machine, whether or not the switch or signal has responded to the movement of the lever. To supply this information, the indication already referred to has been introduced. That particular feature (the information it affords to the leverman) belongs more especially to the operating mechanism, which will be described later on, and at present we shall only describe its application, as a substitute for latch locking. For present purposes all that need be said of it, therefore, is that the movement of a switch, signal or other operating device, closes an electric circuit which passes through the coils of an electro-magnet placed in the frame of the interlocking machine, the armature of which is attached to a small arm which engages the lever in such a way that only a small part of the stroke can be made until the operating device has done its full work, after which the electro-magnet is energized and raises this small arm from engagement with the lever, so that the stroke of the lever can be completed, thereby unlocking any other lever or levers which it is desired to unlock.

Fig. 21 gives a sectional side view and part-sections of a lever, locking shaft, and indication elec-

tro-magnet for a Union Switch and Signal Co.'s electro-pneumatic, or all electric, machine.

There is a difference between the arrangement for a lever which operates a switch and the arrangement for a lever which operates a signal. The lever illustrated is a switch lever, and it will serve to fully explain the application of the indication, as a substitute for latch locking.

It will be noticed that near the back end of the

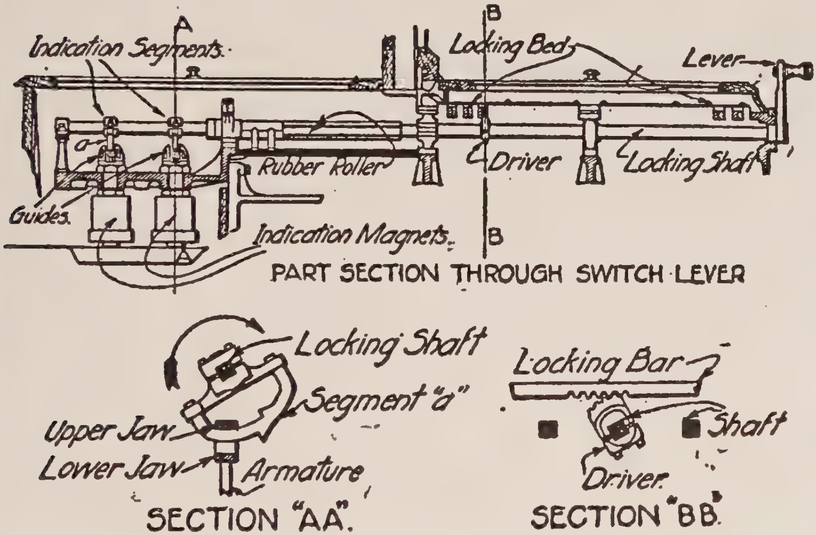


Fig. 21.

locking shaft a segment shown as a in the figure is secured. This segment being on the lower side of the locking shaft swings in the opposite direction to the movement of the lever.

Two small enlargements or teeth are a part of the segment, and a piece of steel with two jaws at one end, in general shape not unlike a common monkey wrench with its jaws open, is placed so that one of the jaws is above and one below the side of the segment on which the teeth are. The distance between the jaws is so laid out that there is just space

enough for one tooth and the segment to pass between them. The other end of the piece of steel is attached to the armature of the indication magnet.

When the magnet is de-energized and the armature down, the lower side of the upper jaw rests on the segment, and there is space enough for the lower tooth, which, it will be noticed, travels in advance of the upper tooth, to pass over the upper side of the lower jaw. The upper jaw will engage the upper tooth, and stop the lever when only part of the stroke has been completed. The lever is, however, allowed to make enough movement to close the path for the electric current by which the switch is operated before the upper tooth engages the jaw. When the switch has made its full travel, the path for the electric circuit through the indication magnet is closed, current flows through it, the magnet is energized, the armature is attracted to the core, and raises the piece of steel so that the upper jaw is lifted from, and the lower jaw presses against the segment. The upper tooth can then pass under the upper jaw, and the lever can complete its stroke. Before completing it, however, it breaks the path of current through the indication magnet, whose armature then drops down and leaves the jaws in the same position as they were in when we started with this description, the teeth in the segment being on the other side however. As the back of the teeth is in the shape of a wedge, when the lever is returned to normal the segment will pass between the jaws without hindrance, so another segment with the teeth turned the other way and another indication magnet are provided to take care of the movement of the lever in the opposite direction to that just described.

Before the upper tooth encounters the upper jaw, the lever has made enough stroke to lock all other

levers which it is intended to lock, but not enough to unlock the levers it will finally unlock, so that the indication acts exactly as the latch locking of the mechanical machine.

In the General Railway Signal Co.'s all electric machine (sometimes known as the Taylor machine, from the fact that it was at one time manufactured by a company of that name), the locking is of the vertical type, and the indication operates as follows: The levers are really plungers which slide horizontally backwards and forwards in the machine frame a distance of 4 ins. In their farthest back position they are normal, and when out as far towards the leverman as they will go they are reversed. For something more than half their length, measured from the back, they are a flat bar of steel ½ in. x 2 ins. The front end runs down to a square bar, ½ in. x ½ in., and terminates in a handle set vertically to the axis of the lever, to give the leverman an easy hold.

In the front end of the flat part of the lever a bent slot is cut. In this slot, which in all is the length of the lever's stroke, a small roller travels. A jaw at the upper end of the tappet is pinned through this roller. When the lever is normal this roller is as near the lower edge of the lever as the slot will allow it to go, and consequently the tappet is as far down in the locking bed. As the lever is reversed the roller is raised, bringing the tappet up with it, and accomplishing the necessary locking.

It should be noted that the tappet in this type of locking moves *upward* from normal, while in the type of vertical locking already described, it moves downward. This has no effect on the movement of the dogs.

For a small part of the stroke the tappet is raised. Then as the slot becomes horizontal it remains

stationary, and finally near the end of the lever's stroke, is raised again, completing the locking.

Alongside the lever is another bar or plate rigidly attached to the machine frame, and pivoted to whose side are three dogs, so as to be immediately below the bottom of the lever. Each of these dogs is held in position by a flat spring. Three long notches are cut in the lower side of the lever. The first of these dogs, a, engages one of the notches; the second, b, engages the first dog. The indication magnet is placed below the lever. When energized its armature raises a rod which engages the dog b already referred to.

When the leverman first starts to reverse his lever, its bottom edge slides along the top of the first dog a until the end of the first notch is reached. The bottom edge of the lever then bears down on the front end of this first dog a, and raises its back end, which is then free to move upward as the third notch is over it. This releases the second dog b, the upper end of which is thrown forward by its spring, so as to come in under the back end of the first dog a and hold that end up. The raised back end of the first dog a next encounters the back of the third notch in the lever, and the lever's further movement is stopped until, the indication magnet being energised, the rod already mentioned presses up on the lower arm of the second dog b, shoving it back into its normal position and releasing the back end of the first dog a, which is then depressed by its spring, raising its front end, and the lever can be pulled out to its full stroke.

Fig. 22 will serve to illustrate this if the reader will carefully go over the above description with the figure before him.

In setting the lever normal after it has been reversed, the indication acts in practically the same

manner. Dog c which has been pulled into position shown in B by the engagement of the lug e with the side of the notch h is set back into the position shown in A by the first inch or two movement of the lever. The dog c, as it turns, forces the dog b

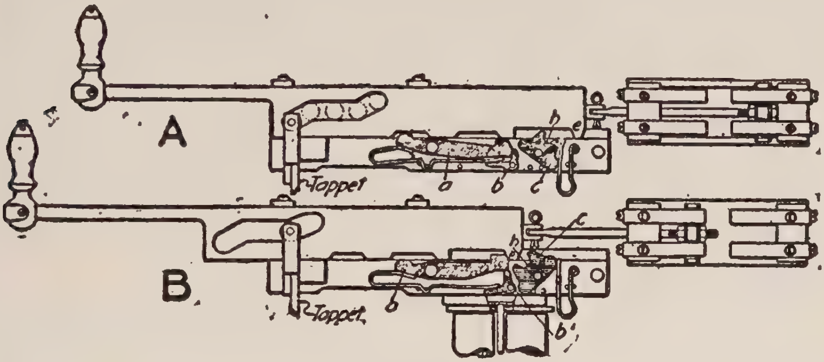


Fig. 22.

into the position shown in B at exactly the right instant.

Further on we will discuss the subject of interlocking more fully in connection with the drawing up of locking and dog sheets for specific cases. The foregoing description will serve to give the reader a general idea of the mechanical methods followed to accomplish it in the machines. We will, therefore leave the subject for the present and take up locking and operating devices, and the manner in which the leverman controls them through the interlocking machine.

CHAPTER V.

LEADOUTS AND GROUND CONNECTIONS.

In the United States it is the universal practice with mechanical interlocking plants to transmit the force exerted on the levers by the leverman to the mechanisms by which the switches, signals, etc., are moved by lines of pipe or by wires.

Where pipe is used it is 1 in. inside diameter, and about 1¼ ins. outside diameter. Where wire is used, it is galvanized steel, generally No. 8, 8½, or 9. The movements of switches locks, movable point frogs, and in short everything except signals, are operated through pipe connections. It is also the more general practice to operate home signals by pipe connections. Distant signals, except as will be noted later, are operated by wires, and dwarf signals are most frequently wire connected, although quite a few signal engineers prefer to operate them by pipe lines.

Starting with the interlocking machines: these may be placed either in the upper story or ground floor of a building, though more generally they are placed in the upper story. We will discuss machines so placed first. Fig. 23 shows the side view of a lever for a machine so placed, to which a pipe line is to be attached. It should be noted that the lever is bent around at almost a right angle. In the end farthest away from the handle a hole is drilled, and what is known as a solid jaw (see Fig. 23), is attached to the lever by a turned pin, of ⅞ in.

diameter, which is kept in place by a spring cotter passed through a hole in its end.

The jaw is continued into a piece of 1 5-16 in. round iron, the other end of which is *tanged;* that is, it is reduced to one inch in diameter, with an even shoulder around it, as is shown in the figure. Just beyond this shoulder where the iron is still

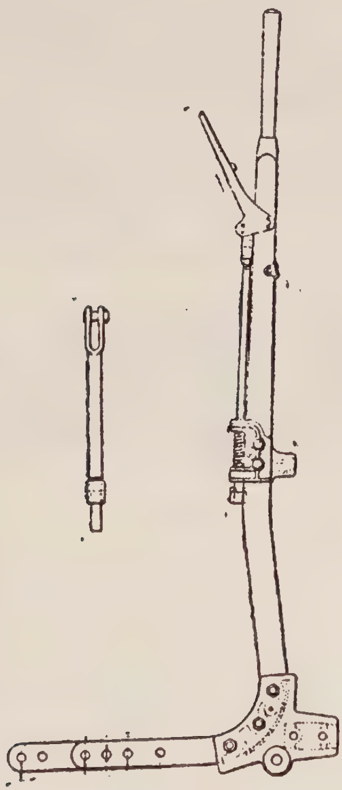


Fig. 23.

1 5-16 in. in diameter a thread is cut for about 1 in., better a little more, and a pipe coupling is screwed on. A hole ¼ in. in diameter is punched or drilled through the small portion as shown. The end of a 1 in. pipe, which is threaded to fit the coupling, is passed over the 1 in. portion of the tang and

screwed into the coupling until its end butts nearly or quite up against the shoulder, after which a hole is punched through it, corresponding to the hole in the tang and a ¼ in. soft iron rivet put through and riveted down.

In case one length of pipe is not sufficient to reach from the machine to the lower floor of the building another length of pipe may be joined to the first length, as follows: Each length of pipe is threaded on both ends. On one end a coupling is screwed; on the other end there is no coupling. In the end on which the coupling is screwed, a so-called plug is inserted. This plug, see Fig. 24, is a piece of 1 in. round iron cut to the required length, and inserted for one-half its length in the end of the

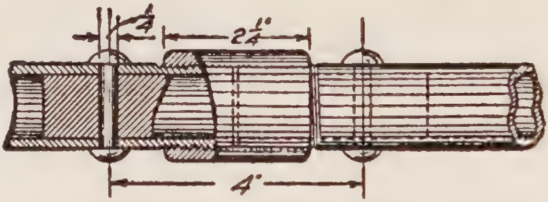


Fig. 24.

pipe, where it is held in place by one or two ¼ in. rivets. The other half of its length is left projecting beyond the end of the pipe, and the second length of pipe can be attached to the first exactly as described for the tang end of the jaw.

As a rule one length of pipe is more than sufficient to reach from the machine to the ground floor of the building, but this method of jointing the pipes is used wherever two pipes are joined, so the description is as appropriate here as it would have been further on.

When a pipe line of sufficient length to reach from the lever nearly to the ground floor has been secured, another jaw is fastened to the down end

of the pipe just as the first jaw was fastened to the upper end.

When the ground floor is reached it is necessary to change the direction of the pipe line from vertical to horizontal.

There are three accepted methods of doing this, as follows:

(1) By using vertical cranks.
(2) By using rocking shafts.
(3) By using vertical deflecting bars.

Fig. 25 shows, a, a vertical crank and b a vertical deflecting bar.

In the case of the vertical crank and the deflecting bar, it is easy to see from the figure how the

a b

Fig. 25.

jaw at the lower end of the pipe connecting with the lever is pinned to that, just as the jaw at the upper end was pinned to the lever. With the rocking shaft this it not quite so apparent, and a short description will here be given. The rocking shaft is a bar of hexagonal, round, or preferably, square iron or steel, which as per Fig. 26, is supported horizontally in a vertical plane parallel to the vertical plane in which the pipe leading down from the lever moves. To its end a crank is attached which swings in a plane perpendicular to the axis of the rocking

shaft. The jaw in the lower end of the pipe, which in the case of the rocking shaft must be so fitted that its opening is at right angles to the opening in the upper jaw, is pinned to this crank. When the lever is moved backwards and forwards, a rotary motion is imparted to the rocking shaft. Another crank is attached to the rocking shaft at right angles to the axis of the first crank.

As a general thing the buildings in which interlocking machines are situated, and especially those where the machine is placed in an upper story, are built so that the row of levers in the machine is paral-

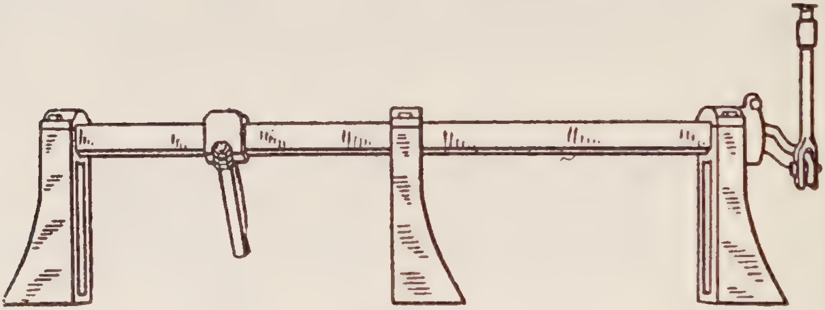


Fig. 26.

lel to a track in front of the building, and the position of at least some of the switches or signals to be operated requires that the lines of pipe by which they are operated should turn away to the right or left hand as soon as they get outside of the building. The rocking shaft is peculiarly well adapted for this, as another jaw can be pinned to the second crank and a pipe line attached to it whose direction is at right angles to the axis of the rocking shaft and parallel to the row of levers.

Where the vertical crank or the vertical deflecting bar is used, this turn is not so easily made, but requires the introduction of an additional crank or deflecting bar laid horizontally and connected, by a piece of pipe with a jaw fastened to each end, to the arm

of the vertical crank not connected to the lever, or to the lower end of the vertical deflecting bar. Sometimes for the sake of economizing space, several horizontal cranks are placed in one frame. This is called a box crank.

Fig. 27 shows a single, generally called "one way" horizontal crank, a horizontal deflecting bar, and a six way box crank.

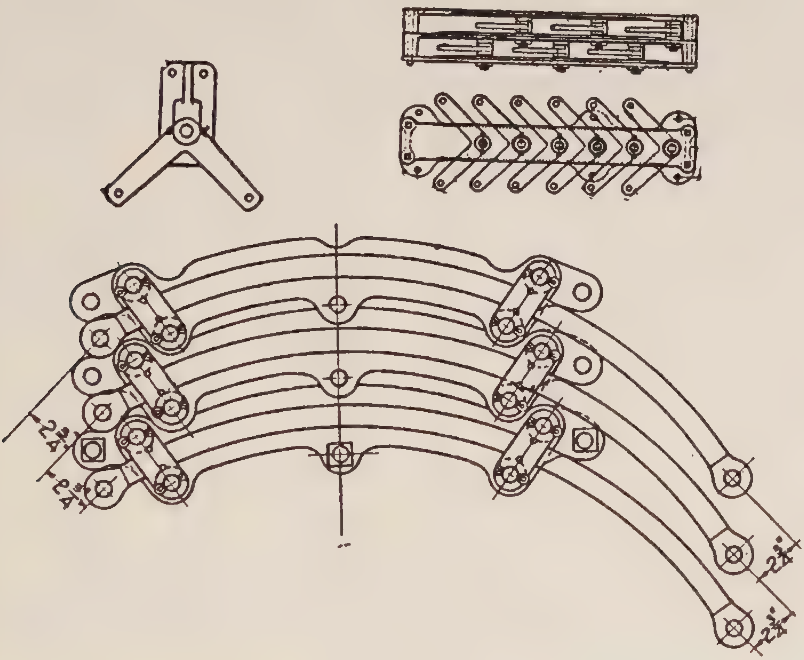


Fig. 27.

The arrangement of vertical cranks, rocking shafts, vertical deflecting bars, the connections between them and the levers, horizontal cranks, box cranks or horizontal deflecting bars and connections between them and the vertical cranks or deflecting bars, by which the direction of the power of the lever is changed immediately in front of the building, taken together, is known as the *lead-out*.

Where a building is built especially for the shelter of the interlocking machine and the attending lever-

men, and in which the machine is placed in an upper story, it is known as the *tower,* and wherever hereafter in this work I use the name lead-out or tower, the foregoing should be taken as an explanation of these terms.

Fig. 28 shows a side view of three levers connected respectively to a rocking shaft, a vertical crank, and a vertical deflecting bar.

It may be said in passing that for neatness of appearance it is always better, when possible, to build the entire lead-out of one device or the other.

Where signals are operated by wires for reasons

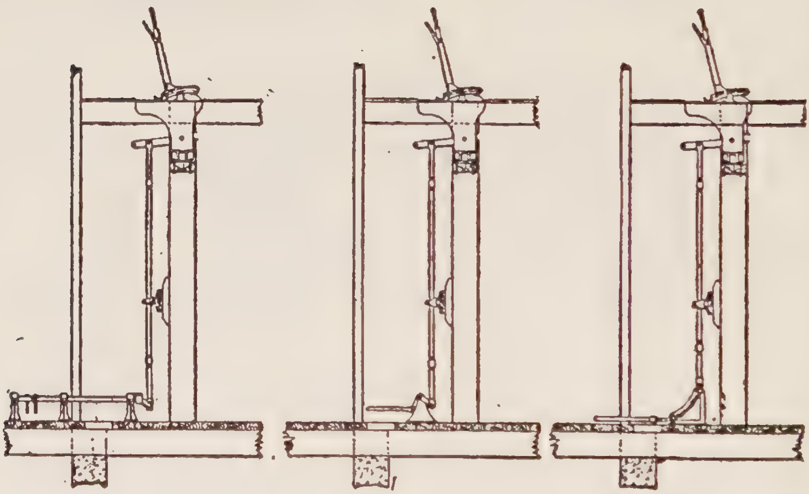


Fig. 28.

which will be explained more fully later, two wires are now always used. The lever then has an addition extended from its front, as shown in Fig. 29, to which one of the wires is attached, known as the tail lever, the other wire being attached to the back end of the lever the same as a pipe line.

When the lever is reversed, one wire is pulled on, while the other one is slacked away, and when the lever is set at normal again this process is reversed.

The method of fastening the wires to the levers is to provide a clevis, known as a *shackle,* or an *adjustable connector* which slips over the tail lever and back end of the lever proper and is held in place with a set screw. Through this shackle or connector a grooved metal eye, known as a *wire eye,* is passed. The wire is then passed around the groove in the wire eye and wrapped several times around itself.

On the ground floor of the tower two iron pulleys, known as vertical chain wheels, are placed. Pieces of one-quarter inch straight link chain, about four feet long are run through these pulleys. A split link is slipped through the end link of the chain, a wire eye passed through that, and the wire attached to the wire eye in the manner already explained.

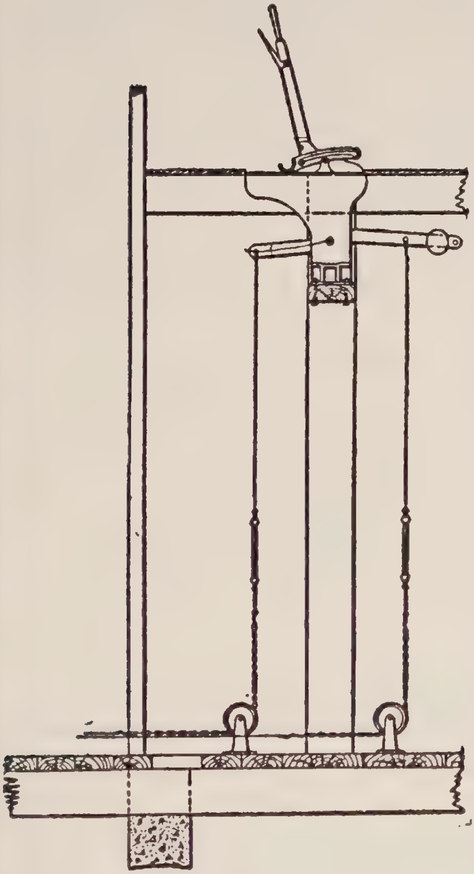


Fig. 29.

The introduction of this chain is necessary in order to have a flexible belt around the pulley large enough not to pass between the pulley and its frame, and besides this, if the wire itself was run around the pulley, the constant bending and then straightening out it would be subjected to would soon break it.

If it is desired to change the direction of the wire line in front of the tower, a horizontal chain wheel

with two sheaves is used. If there are several wire lines to be changed, several of these wheels are put together in one frame, and are then known as a box chain wheel. The chain wheels, both vertical and horizontal, placed inside of or immediately outside of the tower, are also included in the term lead-out.

Where machines are, like those we have just been considering, arranged to be placed in upper stories of the tower and to connect through vertical pipes or wires with vertical cranks, vertical deflecting bars, or with rocking shafts, or vertical chain wheels, they are said to be vertical lead-out machines.

Where they are arranged to be placed on the ground floor of the building, they are said to be horizontal lead-out machines. Either horizontal or vertical locking beds are used with vertical lead-out machines. Horizontal lead-out machines almost invariably have horizontal locking beds.

In horizontal lead-out machines, the levers are not as a rule fulcrumed at their lowest point, but at a point part way up the leg of the machine. An exception to this rule is one type of the Stevens machine. The levers have no bent ends and are connected by jaws and pipe directly to horizontal deflecting bars or cranks. Rocking shafts are not used with these machines. Where a lever operates a wire line, one of two arrangements is usually adopted:

(1) The lever, by jaws and pipe, is connected with one arm of a three-arm horizontal crank to the other two arms of which the wires are connected by shackles or adjustable connectors. See Fig. 32.

(2) The lever, by a jaw, is connected to a short pipe line into which a so-called *pipe lug* is introduced by its tang ends. A piece of 1/4-in. straight link chain is attached to this lug and is then rove back around the pulley of a vertical chain wheel. The end of the pipe not attached to the lever is supplied with a shackle to which the wire is in turn attached.

A movement of the lever in either case therefore pulls on one wire and slacks away on the other. Fig. 30 will serve to make this description clear at a glance.

After leaving the tower the pipe lines are guided and supported by *pipe carriers.*

A pipe carrier consists of two stands or sides made of malleable or cast iron between which is supported a *bottom roller* and a *top roller,* spaced far enough apart to allow the pipe to move freely between them. Where the pipe crosses a track these pipe carriers are supported by a wrought iron or malleable iron bridge, the ends of which are fastened to two adjacent ties, and are then called *transverse pipe carriers.* Where the pipe lines run out in the open the pipe carriers are fastened to what are known as *pipe carrier tops.* These tops in turn are fastened to foundations which are buried in the ground.

The pipe carrier sides or stands are so arranged that

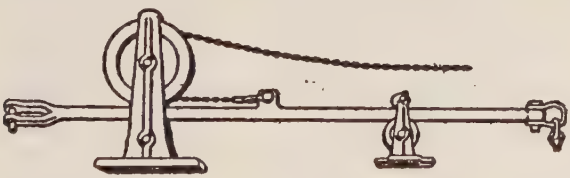


Fig. 30.

in case several pipe lines run parallel to each other, one side can be added with an additional top and bottom roller and space provided in that way for another pipe. With all the parts assembled pipe carriers are generally designated by the number of pipes they carry parallel to each other, as *three way, four way, five way,* etc., meaning that they are arranged to carry three, four, or five parallel pipes. A three way pipe carrier would have four sides or stands, three bottom and three top rollers, and in all cases a pipe carrier of any given way will have one more side than the num-

ber of way, and as many of each of the top and bottom rollers as there are ways.

Generally speaking the tops to which the pipe carriers, other than the transverse, are attached are blocks of oak wood, 3 ins. x 8 ins. in section, and cut to the required length, and the pipe carrier sides are fastened to them by lag screws. There are one or two metal tops now on the market which are used to some

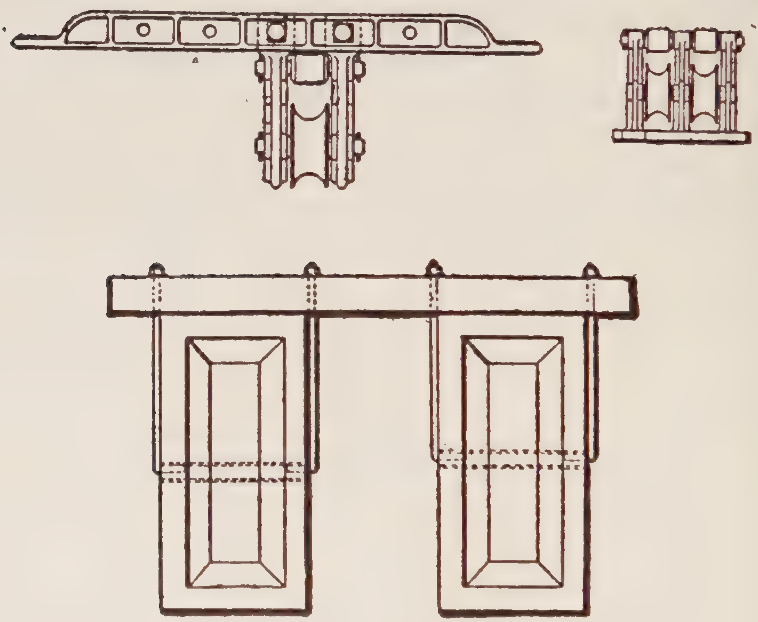


Fig. 31.

extent, and the use of which will no doubt become more general as the price of lumber advances.

Formerly it was the general practice to make these tops part of a rectangular wooden frame much like the four sides of a box, which was buried in the ground with one side exposed and acted as a foundation and top as well; but of recent years the foundations have been made of concrete or cast iron, and the tops bolted

to them. Probably 90 per cent of modern installations use concrete foundations.

Fig. 31 shows a one way transverse pipe carrier, a two way ordinary pipe carrier and a top which is fastened to two concrete foundations of a form very frequently used.

Some designs of transverse pipe carriers have no top roller and there is another style of pipe carrier, known as a *special wrought pipe carrier,* which has no top roller and is intended to be screwed down to the end of the ties where it is necessary to run pipes very close to the rail. Their use at interlocking plants is generally confined to locations around switches, or to steady the up and down pipes leading from the levers to the floor of the tower with a vertical lead-out machine. They will be shown in some of the figures which will appear later.

As all pipe lines end with jaws which are pinned to the levers, cranks, etc., with ⅞ in. round pins, the unit

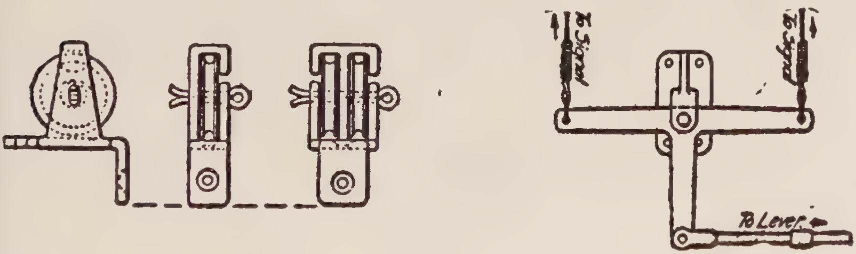


Fig. 32.

of strength for any pipe line may be considered as that of a ⅞ in. round pin in double shear. The pipe line may be considered as a hollow column supported at each end; and calculation and experience have shown that the pipe carriers should not be placed more than 7 ft. apart in order that the pipe will not bend sideways before the pins give way. Some signal engineers place them 7 ft. apart on straight lines, and 6 ft. apart on curves.

Wires after they leave the tower are generally sup-

ported by small metal pulleys known as *wire carriers*, a popular form of which is shown in Fig. 32.

As long as there are pipe lines going in the same direction as the wires, these wire carriers are fastened by screws to every fourth pipe carrier top, so as to space them 21 ft apart. As the wire is never in compression there is no mathematical reason for this distance, and where pipe carriers are spaced 6 ft. apart the wire carriers may be placed on every fourth top as before, making them 18 ft. apart instead of 21 ft.

Where the wires go out to distant signals they generally extend far beyond the pipe lines, and then it is customary to drive oak stakes 3 ins. x 4 ins., and 4 ft. long, pointed at one end, every 21 ft., and to screw the pipe carriers to the tops of these stakes.

The row of stakes is generally set parallel to the track, and if the track happens to be curved, the tops of the stakes are sawed off on a bevel and the wire carriers are set at an angle to the vertical, so that when the wire is in tension the force exerted by it against the rim of the pulley wheel will bear directly against the pin on which the pulley wheel turns. This is done in order to get the mechanical advantage of the pulley, and not have the wire scraping against the side of the frame of the wire carrier as it would do otherwise.

A wire carrier which is hinged in such a way that it may be set at any desired angle and then clamped in that position is used to some extent. Its use obviates the necessity of bevelling the top of the stakes.

Attempts have been made from time to time to introduce metal wire stakes, but it can hardly be said that their use so far has become standard practice, most signal engineers still retaining the oak stakes.

To return to the pipe line. Where a moderate curve such as following the curvature of a track up to 8, or on page 79.

even 10 degrees, is to be made in it, the pipe may be sprung a little to follow this curve.

The middle ordinate for a 7 ft. chord of a circle with the radius of a 10 degree curve is only about ⅛ in.

Where, however, a sudden turn is to be made, such as might be necessary at the angle of a crossing of two railroad tracks, horizontal deflecting bars, radial arms, or cranks are introduced.

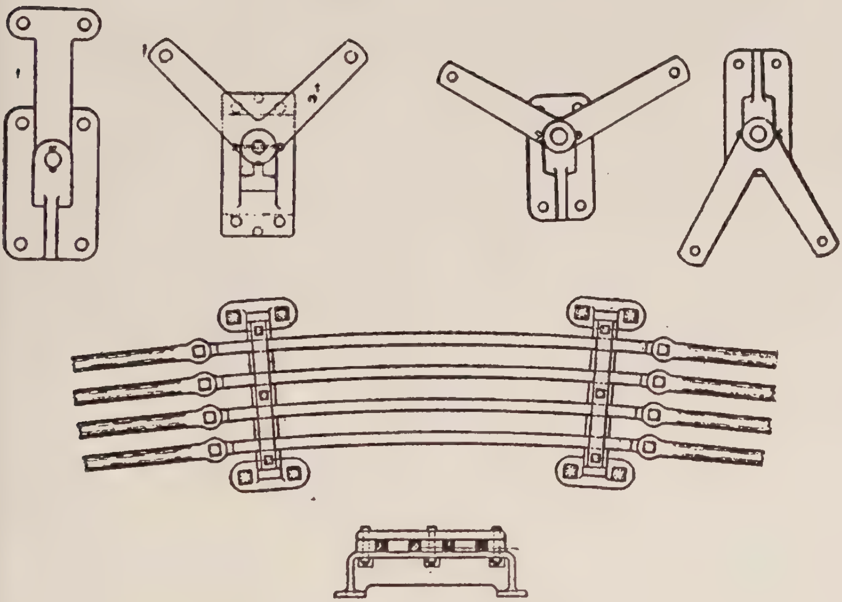


Fig. 33.

The deflecting bars used in such cases are similar to those already described, except that they do not generally make a complete 90 degree turn in the pipe line. In fact where the turn is greater than 45 degrees the use of cranks will be found more satisfactory.

Radial arms are not much used except where a pipe line crosses a track between the ties, and is then turned so as to cross another track which does not run quite parallel though nearly so to the first track. By far the most common device for effecting turns is the hori-

zontal crank. By bending its arms a turn of almost any angle may be made in the pipe line.

Fig. 33 shows a three way horizontal deflecting bar, a one way radial arm (these radial arms are made up to three way) and a right angle, an obtuse angle, and an acute angle crank.

As before stated the levers in the interlocking machine are spaced 5 ins. apart, center to center, and of course the vertical cranks, vertical deflecting bars or rocking shafts in the lead-out are so spaced also. The pipe carriers are so arranged that parallel pipe lines after leaving the lead-out are spaced 2¾ ins. apart, center to center. The box cranks or any other horizontal cranks used in the lead-out, therefore, must be so arranged that the pin holes in one arm must measure 5 ins., center to center, while in the other arm they must measure 2¾ ins., center to center. With the rocking shaft this change of spacing is easily effected, as the crank on the body of the shaft may be driven along it to any desired position.

CHAPTER VI.

COMPENSATION—OFFSETS—FOUNDATIONS.

Having now seen how we bring the pipe lines from the levers in the tower out onto the ground, and how we can then turn them in any direction we please, we will say a few words on *compensation,* which is by far the most important item to be taken into consideration in the ground work of a mechanical interlocking plant.

It is a well-known fact that iron and steel expand when heated, and contract when chilled; and the pipe in an interlocking plant being subjected to the effect of the hot sun of summer and the bitter cold of winter, lengthens and shortens considerably. Roughly speaking, iron and steel expand about 1 in. in 100 ft. for each 100 degrees Fahrenheit rise in temperature, and contract correspondingly. As there are many sections of the United States where it is not uncommon to have temperatures of 100 degrees in the sun in summer, and of 25 to 30 degrees below zero in the winter, and as pipe lines are frequently over 1,000 ft. long, it can easily be seen that this expansion and contraction is a very serious matter.

In order to neutralize its effect, compensators are let into each pipe line. The established rule is to have a compensator in each pipe line over 50 ft. in length and up to 800 ft. in length. For pipe lines over 800 and less than 1,200 ft. in length a compensator with longer arms is used. For pipe lines over 1,200 ft. two or more compensators are provided.

The simplest form of compensator is a straight bar pivoted in the middle in an ordinary crank stand. Suppose a perfectly straight pipe line attached at one end to a lever, and at the other end to some device like a semaphore. Also suppose that the lever is latched and cannot be moved, and the semaphore blade is as far as its attachments will allow it to go in the direction that a push on the pipe line would send it. Then suppose the pipe line to be heated so that it will expand 3 ins. It must either break something, or itself bend, carrying the pipe carriers and foundation with it.

Suppose, however, that we cut the pipe line in two

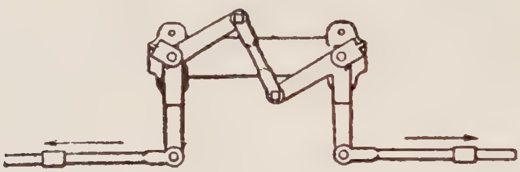


Fig. 34.

in the middle, attach a jaw to each of the ends (we are supposing that pipe equal in length to the two jaws will be cut out) and pin these jaws to the ends of the compensator arm. Now when the half of the pipe between the compensator and the lever expands its 1½ ins., the lever end being held fast, the compensator end will move, taking the end of the compensator arm to which it is attached with it. At the same time the other half of the pipe line which is held fast at the signal, is expanding just as much towards its compensator arm, and we have two parallel forces acting in opposite directions on either end of an equal arm lever which simply tends to turn the lever around on its fulcrum.

In actual practice this type of compensator is awkward to use because it makes a jog in the pipe line wherever introduced, and the so-called *lazy jack com-*

pensator which keeps both parts of the pipe line in the same vertical plane has been designed.

Fig. 34 shows one of these devices. It consists of an acute angle crank, and an obtuse angle crank, both pinned to one frame and a link connecting them. A glance at the figure will show the reader how a pull on one pipe in the direction of the arrow will make a corresponding push on the other pipe in the opposite direction, and yet both pipes remain in the same vertical plane, allowing, of course, for the slight sidewise movement which the end of the crank arms give them as they swing, which is so slight it may be disregarded.

As each foot of the pipe line expands or contracts as much as and no more than any other foot, it is easy to see why when only one compensator is provided, it should be placed in the middle of the line to be compensated. If this was not done, as the arms of the compensators work together, they would travel as much as the longer pipe line expanded or contracted, and as the shorter pipe line would not expand or contract as much it would either be subjected to a severe tension or compression, which might break it or bend it, or give a wrong movement to the switch or signal.

The amount of contraction or expansion which can be taken up by one lazy jack compensator is limited and the use of compensators with different sized cranks is often inconvenient. In actual practice I have found it worked out very well to let a compensator into each line 50 ft. to 650 ft., to have two compensators in every line 650 to 1,300 ft., three compensators for 1,300 to 1,950 ft., and so on.

Where two compensators are used in a line, the distance to be compensated should be divided into four equal parts, and the compensators should be placed at the first and third points of division so that there is just twice as much pipe line between the two compen-

sators as there is between either compensator and the fixed end nearest it. Each compensator will then take up one-half of the expansion or contraction of the line between it and the other compensator which will be equal to the expansion of the line between it and the nearest fixed end.

With three compensators the line should be divided into six equal parts and the compensators set at the first, third and fifth points of division.

It should be thoroughly understood that a compensator always *reverses* the direction of application of the power. That is, if the pipe on one side is being shoved

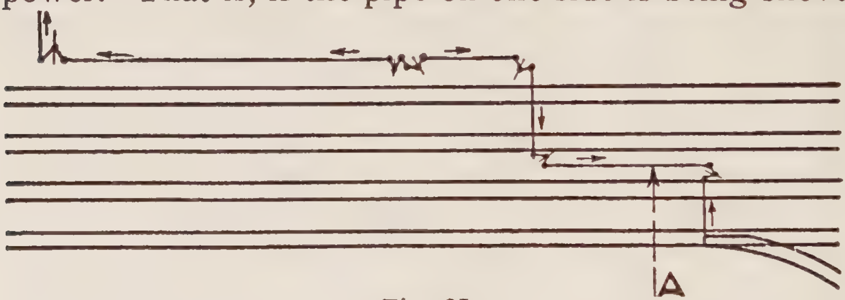


Fig. 35.

toward the compensator this will be changed into a *pull* on the pipe on the other side.

So far we have considered only compensation in straight lines. If any cranks are introduced into a line to change its direction, they may or may not have an effect upon the placing of the compensators in that line.

Fig. 35 shows a pipe line connected to a vertical crank, the other arm of which is connected to a pipe line in which several horizontal cranks are introduced. The paper is supposed to represent the plane of the ground, and for convenience of illustration the vertical crank is shown as if it was laid down on its side. If the lever is reversed it will be readily seen that a pull is exerted on the pipe line up to the compensator. There it is reversed and changed into a shove. We will as-

sume, however, that it is necessary to have a pull at the switch, and the last crank, it will be seen, is set around in such a way that a shove on one arm will produce a pull on the other. This crank, therefore, acts exactly as a compensator does in addition to its regular duty of changing the direction of the pipe line. In laying out the compensation, therefore, a distance equal to that from the crank to the switch should be laid out on the other side of the crank, and the length of pipe which the regular compensator is to take care of should be figured from this point, shown as A in the Fig., and the compensator placed half way between A and the lever.

Besides the solid jaws already described, what are known as screw jaws are also used to some extent. One of these is shown in Fig. 36. The principal dif-

Fig. 36.

ference between it and the solid jaw is that the jaw part is threaded and can be screwed backward and forward on the shank so as to lengthen or shorten the pipe line. These are useful in taking up wear, slight variations in length of pipe line caused by the settling of foundations, etc. Some signal engineers use them to connect the pipe lines to the arms of the compensators, instead of solid jaws, but more generally their use is confined to connections to switches, locks and signals. Turn buckles called *point adjusting screws* are also frequently let into the pipe line for adjustment purposes. It is good practice to have at least one in every pipe line. To have one somewhere in the line on each side of each compensator, unless one end or the other terminates in a screw jaw, in which case the point adjusting screw may be omitted, will be found very convenient.

Where there are several pipe lines running parallel, and a compensator is to be let into one of them, it must be placed in a different horizontal plane (on a different level) usually below the pipe lines so as not to interfere with them.

The jaws by which the pipes and compensators are connected are then bent as shown in Fig. 37 so as to make an offset, and the compensator arms move freely below the other pipes.

It is frequently necessary to offset jaws connecting pipe lines with cranks, deflecting bars and radial arms in the same way. These offsets should not be greater than 2¾ ins. in one place. If more is needed the crank arms or whatever the pipe is to be connected to, may be given an additional offset in the other direction, not to exceed 2 ins., so as to make 4¾ ins. change in all, and if it is a crank the other arm can be offset another 2 ins., making 6¾ ins., and the other jaw may be bent

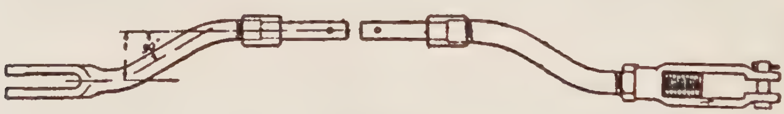


Fig. 37.

like the first, giving a total of 11 ins. Where a greater offset than 2¾ ins. is required in the pipe line at some point where no compensator, crank, radial arm, or deflecting bar is placed, a bar of 1¼ ins. round iron, tanged on each end should be let into the pipe, and as many 2¾ ins. offsets placed not less than 1 ft. apart, made in that as is necessary to total the required offset. This sort of work, although permissible and strong enough, never looks well, however, and should be avoided wherever possible.

Where a certain amount of offset is required at a crank it always looks better to divide it equally between the two jaws and the two crank arms. *The pipe itself should never be bent.*

Where wire connections are used the wire of course expands and contracts, just as the pipe does. As it is never drawn very taut when first put in there is little chance of its contracting enough to break. Its supports being set 21 ft. apart, it is bound to sag down more or less between them, and to a certain extent acts as its own compensator in that way.

As before stated, wire adjusting screws are universally provided in the base of the tower, so that in case of any very sudden changes in temperature the leverman in a minute or two can readjust the wires.

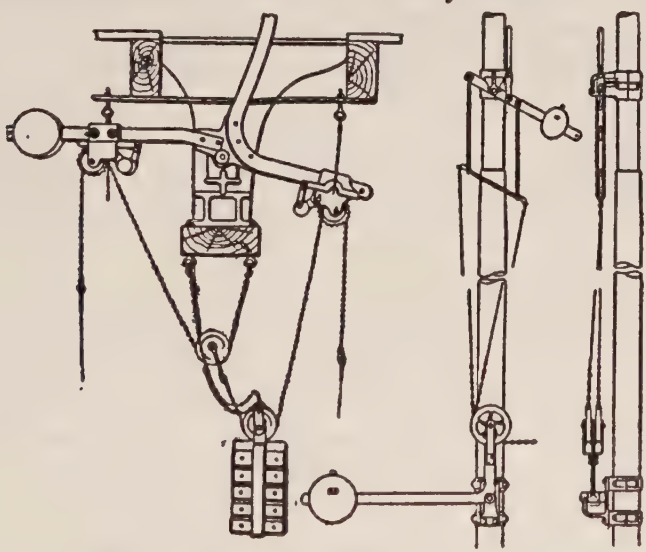


Fig. 38.

Nevertheless wire compensators have been invented and are to be had from the dealers, although their use is very limited at the present time. Fig. 38 shows two separate designs, the principles of which are so self-evident that I shall not describe them in detail.

Cranks, compensators, deflecting bars, radial arms and chain wheels are usually supported on concrete foundations buried in the ground. These foundations are made very much larger than those already men-

tioned, which support the pipe carriers, because they are actually subjected to the strain on the pipe or wire line when the leverman moves his lever. Nothing is more vexatious than to have one or more of these foundations move after an interlocking plant is completed, and if there is any doubt as to the solidity of the ground it is best to stand on the safe side and be sure to make them large enough.

I have found the following sizes to be a good average, but as before stated if the ground is marshy or very light they had better be made larger.

For cranks: 26 in. wide, 26 in. long and 3 ft. deep.

For compensators: 26 in. wide, 52 in. long and 3 ft. deep.

For deflecting bars, 24 in. x 24 in. x 3 ft.

For radial arms and chain wheels: 24 in. x 24 in. x 3 ft.

On account of their size it is not convenient to ship them around; and the quite general practice is to dig a hole of the proper dimensions, suspend the crank, compensator or whatever device is to be set, in its proper position over the hole, and fill in with concrete. In sandy, loose soils, it is frequently necessary to make forms to reach to the bottom of the hole, but in stiff soils a form around the top to give that part of the foundation which shows above ground a neat appearance is all that is necessary. *It is very important that the bottom of the hole be kept level,* so that the concrete will set with a flat base. If the sides are allowed to cave into the hole, the concrete foundation or block is apt to be made with a rounded bottom, and is then more likely to rock when a strain is put on the pipe line than it would be if it stood on a flat base.

The cranks, compensators, etc., are secured to the concrete block in one of three ways:

(1) By being bolted to blocks of oak through which and extending out from their lower side, are 4 ¾-in. hook bolts long enough to reach nearly to the bottom of the concrete, which is filled in around these hook bolts.

(2) The same as above, except that the oak block is omitted and the upper ends of the hook bolts are passed through the base of the device to be fastened down.

(3) By using cast iron legs or piers, the tops of which are grooved so as to take the head of a short ¾ in. bolt slipped in from the end of the groove. The thread end of the bolt is passed

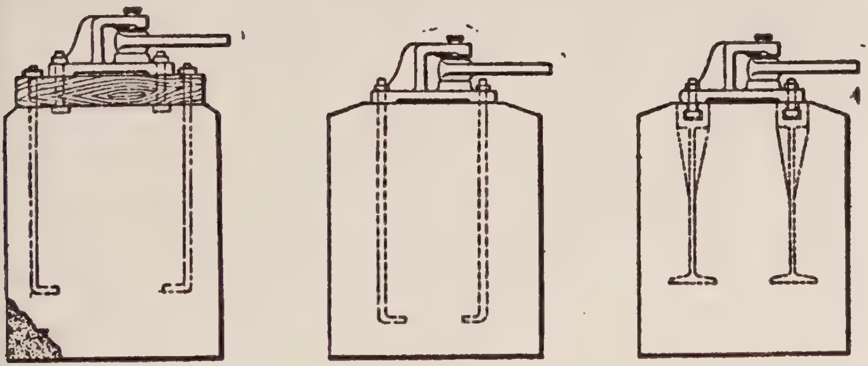


Fig. 39.

through the base of the device and the nut then put on and screwed down. Two of these piers are used for each device.

Fig. 39 shows a crank fastened to its foundation in each of the three ways.

The first method is little practiced now. The tendency is to do away with the use of wood as much as possible at interlocking plants.

The second method allows of no sidewise adjustment in case the foundation should move, which is unavoidable at times on new fills.

The third method is excellent practice, although

if the nuts loosen the bolt heads may slide along the grooves and allow the device to move sidewise when it should not. It cannot move far, however, and may easily be driven back into place, and the bolts tightened up.

The tops of all foundations should be neatly finished off with grout. It is generally a sign of a good foreman if he takes pains to leave his foundations looking well.

CHAPTER VII.

LOCKING AND OPERATING DEVICES.

Our next step brings us to the operation of switches.

The simplest way to do this, of course, is to let the pipe line which is to operate the switch run along side of and parallel to the track in which the switch is, and when reaching a point opposite the head rod of the switch, to set a crank and connect its arms, one to the pipe line leading from the machine and the other to the head rod of the switch. To a certain extent this is the method followed. However, it would not be safe to depend on this alone, as the switch might be 600 or 700 ft. away from the machine and entirely out of sight of the leverman, and as the pins, jaws, crank arms, etc., are wearing all the time, enough lost motion is soon made in the pipe line to prevent the leverman detecting the presence of some hard substance like a stone between the switch point and the stock rail, which might spring the switch point enough open to cause a derailment.

The most approved method of operating a switch is as follows: The pipe line is led up to the head rod just as described. The lever which operates a switch gives the pipe line a movement of 8¾ ins. which is carried up to the last crank arm. As the throw of switches is not often over 5 ins. we want to lose 3¾ ins. of stroke between the crank and the switch point. We could, of course, shorten one crank arm, but the better method is by using what

is known as a *special switch adjustment.* This is an arrangement of a threaded rod fitted with nuts passing through a socket. If the nuts are closed up on the ends of the socket any movement imparted to the rod will move the socket, but if the nuts are moved away from the ends of the socket any amount of motion we please, less than the motion of the rod, will be imparted to the socket. In practice the nuts are followed by jamb nuts which prevent their backing away after being once set, and the socket is fastened to the head rod of the switch.

Fig. 40 shows a very popular form of this device.

Fig. 40.

This is intended to be attached to the head rod between the two points of the switch.

In addition to the special switch adjustment attached to the head rod of the switch, a *front rod* is attached to the points. This front rod which is shown in Fig. 41 is made up of three parts; (1) the rod itself, (2) the right hand *point lug,* (3) the left hand *point lug.*

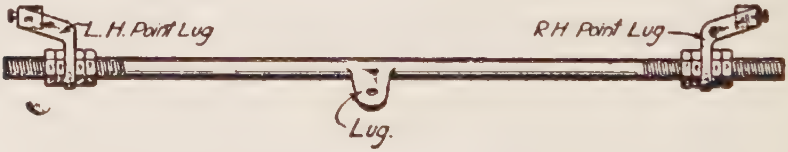


Fig. 41.

The point lugs are bolted to the switch points so as to extend a little beyond their ends, and the rod is attached to each of them so that as the switch is moved from one of its positions to the other, the front rod is given a longitudinal movement equal to the throw of

the switch. In the middle of the front rod is a lug projecting from its lower side, and to this lug is attached the *lock rod,* one type of which quite commonly used is shown in Fig. 42. The lock rod is upported in the same vertical plane as the front rod, and, of course, moves longitudinally backward and forward with the front rod. This lock rod is carried under the main rail of the track in which the switch is situated, and its free end which is outside of the track and is a flattened bar of iron, is passed through a rectangular hole in a casting known as a *plunger block or plunger casting* which is bolted down to the outer end of the same tie on which the ends of the switch points rest.

Fig. 42.

. Cast in this plunger block and at right angles to the rectangular hole through which the lock rod slides back and forth, but in a horizontal plane passing through the center line of the outside end of the lock rod, is a round hole in which a smooth steel pin called the *plunger* can slide backward and forward at right angles to the line of travel of the lock rod.

The end of the plunger which does not enter into the plunger block is shaped into an eye by which it is attached by a jaw, preferably a screw jaw, to a pipe line leading to a lever in the machine, different from the one by which the switch is moved, and so connected that when the lever is reversed the plunger will be shoved forward in the plunger block, and when the lever is set normal again it will be withdrawn until its end clears the rectangular hole in which the lock rod travels.

Now if two holes the same diameter or a little

larger than the plunger are drilled in the lock rod so that when the switch is in its normal position one of them will be exactly opposite the round hole in the plunger block, and the other one so that it will occupy that position when the switch is reversed, it is easily seen that when the lock lever is reversed the plunger will pass through the hole in the lock rod and thereby lock the switch in either position it may be in at the time, but if the switch has not made all of its travel so as to close up against the stock rail, the end of the plunger will strike against the side of the lock rod where there is no hole, and as it can then go no farther the leverman will be unable to get the lock lever all the way over and will know that there is something wrong at the switch. This arrangement is known as a *facing point lock,* and a good deal more will be said about it before we are through.

The use of the facing point lock makes it as certain as human ingenuity has yet been able to make it, that a switch is safe for the passage of a train, but there is one contingency that the lock in itself does not provide against. This is, that a leverman may, thinking that a train has passed entirely over a switch, unlock it and then throw it between the trucks of an engine or car, thereby, if it happens to be a facing point switch, causing a derailment. To prevent this, what is known as the *detector* bar has been designed. This is a flat bar of iron ⅜ in. by 2¼ in. or ½ in. by 2¼ in., with a bevelled edge and generally 50 ft. long, although there is a tendency at present to make them 53 ft. long. This is supported along the outside edge of one rail or the other immediately in advance of the switch points. It is carried by supports attached to the rail, so arranged that as the bar slides backward and forward along the side of the rail, it is raised up and then lowered again. This bar is attached to the same pipe line that moves the plunger, so that every

time the plunger is moved back or forth the detector bar is raised and lowered. The wheels of engines and cars being wider than the tops or "heads" of the rails, as long as a wheel is over the detector bar, it, the bar, cannot rise enough to allow the switch to be unlocked, and its length is such that no equipment used on American railroads has enough space between its trucks to allow a bar to be thrown between them. The supports for the detector bar are known as *rail clips*. There are a good many designs of these. One kind

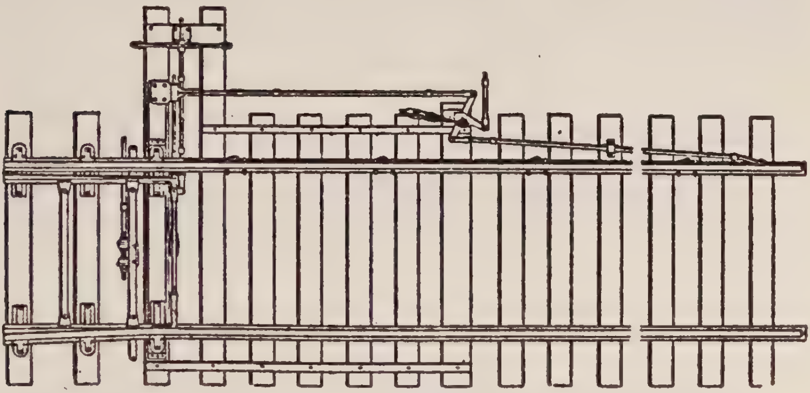


Fig. 43.

operates by a link which is the radius of the sector of a circle, and the other is a cam arrangement.

As it is extremely important that the track at the switch points of an interlocked switch should be kept to its true gauge, it is the general practice to provide a plate of iron about 6 ft. 10 in. long, which is screwed or bolted down to the top of the tie on which the ends of the switch points rest, and to one end of which the plunger block is fastened. This plate known as the *tie plate*, has strips riveted across it against which rail braces are placed, thereby making a very strong support against spreading of the rails. Fig. 43 is a plan of a switch fitted up as above, showing all the parts mentioned and also a *bolt lock*, the use of which will

be described further on when we get to signal movements.

There are times when it is impossible to run the detector bar ahead of the switch, as for instance, in a case where the switch is within ten feet of a railroad crossing, or a paved street. In such cases two detector bars are used, one on either rail back of the points. Fig. 44 illustrates a typical arrangement of this sort.

There is another locking arrangement known as a *switch and lock movement* which is sometimes used. With this the same pipe line which throws the switch also operates the lock and detector bar. This device

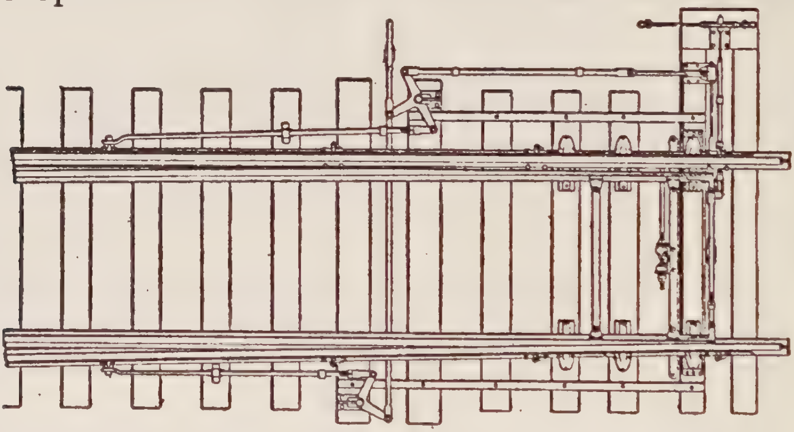


Fig. 44.

is very ingenious. Its main feature is *an escapement crank,* which is a crank one arm of which is shaped into a cam. This cam is so arranged that the first one-third of the lever stroke will not move the crank at all, the second one-third gives the crank its full throw, and the last third again does not move the crank. By having the crank throw the switch and the last third of the stroke lock it and lower the detector bar, we have the complete device. When the movement is reversed the first third of the stroke (which was the last third in the other movement) *unlocks* the switch and raises the detector bar, the

middle third throws it, and the last third locks it again, and drops the detector bar.

There is more than one method of constructing these devices, but the type most generally used at the present time is shown in Fig. 45.

The *slide bar* is attached to the pipe line from the lever, and moves longitudinally as the lever is moved. It is built up of two plates, better seen in the side view, between which is a thimble through which a pin connecting the two plates passes. As the

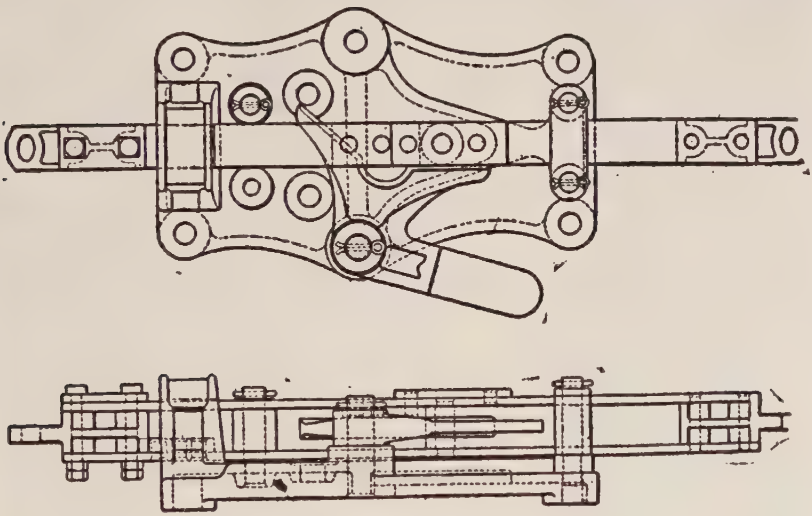


Fig. 45.

slide bar moves back and forth this thimble rolls along the edge of the cam end of the escapement crank, moving the crank as described above, and thereby throwing the switch. On the inner side of each of the plates forming the slide bar a flat dog is riveted. The lock rod passes through the rectangular hole near the end of the frame of the switch and lock movement. Instead of having holes drilled in it, the lock rod has notches cut in its upper and lower edges just large enough for the dogs to pass through. When the slide bar is in its normal position one of these

dogs engages the lock rod, holding the switch locked. As the slide bar is reversed the dog is withdrawn from engagement with the lock rod, thereby unlocking the switch, which remains unlocked for the middle third of the travel of the slide bar, during which time the escapement crank is put in motion, thereby throwing the switch. The final third of the slide bar's travel moves the other dog into engagement with the other notch in the lock rod, thus again locking the switch in its reversed position.

When the lever is set normal again this process is repeated in the opposite direction.

Fig. 46 shows a switch with detector bar ahead of

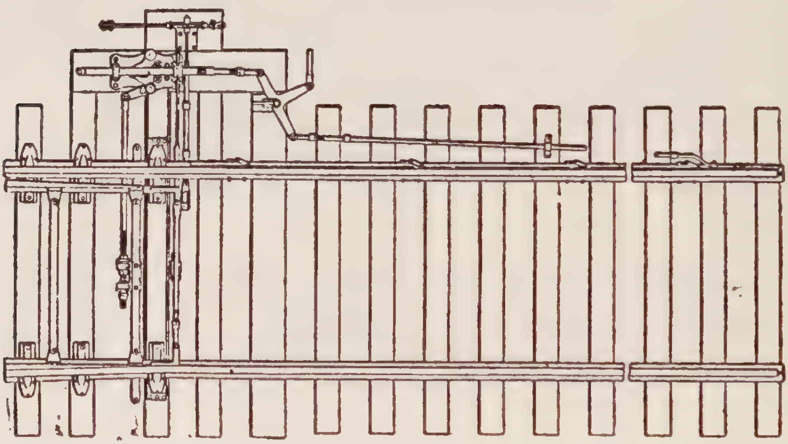
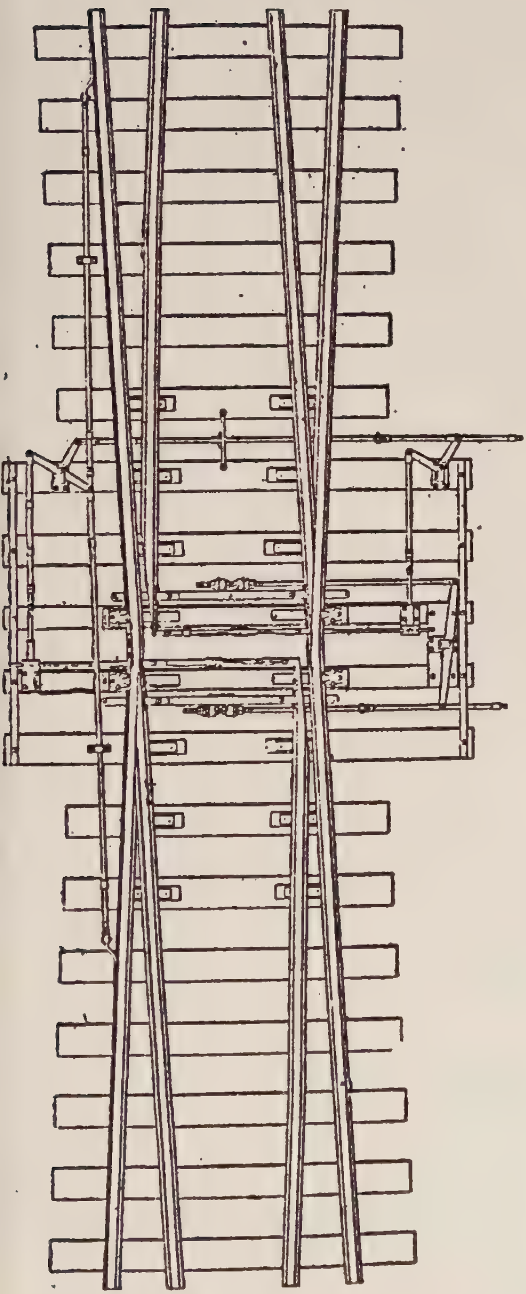


Fig. 46.

the points, fitted with a switch and lock movement. It should be noted that in all essential particulars the fitting up of the switch as regards the special switch adjustment, tie plate, rail braces, front rod, lock rod and detector bar, is the same as for the facing point lock. It will hardly be worth while, therefore, to illustrate a switch fitted with two detector bars back of the points and operated by a switch and lock movement.

Besides operating ordinary switches, interlocked levers are often called on to operate slip switches and



.Fig. 47.

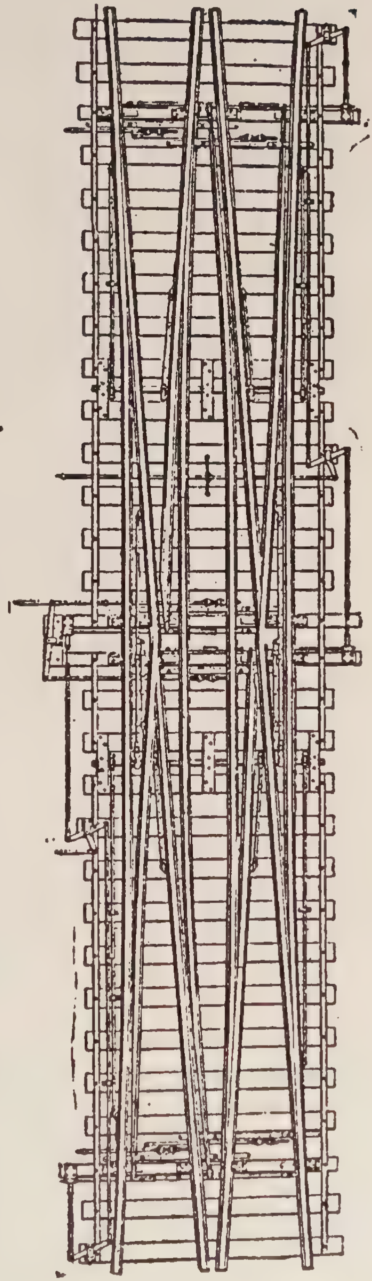


Fig. 48.

movable point crossings. There is no essential difference between the arrangements for this work and for work already described, although the application of the several parts varies somewhat. Fig. 47 shows a movable point crossing and Fig. 48 a double slip switch arranged to be operated by the levers of an interlocking machine. Facing point locks should always be used in such cases to lock the points and not switch and lock movement. In these Figs. it should be noted that a rocker shaft is run under the track connecting the detector bars on the two sides and causing them to work simultaneously. This arrangement is also very convenient at times where there is limited room to set cranks, with switches which are double barred.

It is customary to provide large oak timbers to support the mechanisms at switches and derails. Oak, ten inches by ten inches, and twelve feet long, is a very convenient size for this purpose. With switch and lock movements at least three pieces should be used—one for the three-way crank, one for the tie plate under the points of the switch, and one in place of the first tie back of the switch points to support the other end of the switch and lock movement base. The tie-plate timber may be made narrower than the other two, but it is just as well to use the same size throughout and to adze down the sides of this timber so as to make it the same width as the tie plate on top. This is necessary in order to clear the special switch adjustment.

With facing point locks, two timbers are enough, one to support the plunger casting and one to support the three-way crank, unless a bolt lock is put on the ties, when a third timber may be put in to support it. As a rule, however, it is more convenient to support the bolt lock on a concrete foundation. Some signal engineers use more timbers than I have specified, but I think my list is enough.

CHAPTER VIII.

SIGNALS—BOLT LOCKS—SELECTORS—MECHANICAL SLOTS.

Our next step brings us to signal movements, and we will, of course, discuss those operated by pipe lines, "pipe connected" signals, first.

It is now the universal practice to use iron signal masts for high signals. At one time these were set by being raised in a large hole dug to receive their lower end, which was afterwards filled in with concrete. During the last few years, however, the signals have been made with a large cast iron base, so that they stand on top of the concrete foundation, and are fastened thereto by strong hook bolts which are embedded in the foundation. Dwarf signals have always been made of iron, and like the high signals are bolted to a concrete foundation, which, of course, does not require to be as large as the foundation of the high signal.

High signals consist of the *base;* the *pole,* which is made of three lengths of pipe 6⅝ in., 5 9-16 in. and 4½ in. outside diameter respectively (these are most frequently swaged together at the joints); the *pinnacle* which is a cast iron cap to fit over the top of the pole and keep rain and snow from getting inside of it, as well as to give it a neat appearance; the *arm plate,* sometimes called the *spectacle casting,* which is a cast

iron plate with holes cast near one edge in which the colored glasses or roundels which give the night indications are fixed, and a socket in the opposite edge to which the *blade* is bolted.

This arm plate is fitted on a square shank at the end of a turned axle called the *spindle,* which is supported in a casting called the *arm plate bearing,* which is bolted to the pole near its top.

Generally a *back light* casting, of which more will be said later when we come to night indications, is fastened to the other end of the spindle. An iron ladder is attached to the pole, so that persons may climb it to put up or take down the lamps, and to make repairs.

Near the base of the pole, sometimes a part thereof, is another casting to which a crank or chain wheel may be bolted. The ladder, too, is stayed to the pole to steady it.

With pipe connected high signals, a crank with one arm much longer than the other, known as an "L" crank or counter weight lever is bolted to the base or casting just above the base. The long arm of this "L" crank has a hole drilled in it a few inches from the hub. A screw jaw tanged to fit ¾ in. instead of 1-in. pipe, is pinned to the crank through this hole, and a ¾-in. pipe called the *up and down rod* is carried up to the arm plate parallel to the pole.

This up and down rod is attached to a pin in the arm plate by an *eye rod* tanged on its down end to receive the pipe. The up and down rod is steadied by wrought iron guides clamped around the pole.

A heavy cast iron weight with a hole cored through it to receive the crank arm, called the *counter weight,* is passed over the end of the long arm of the "L" crank and held by a set screw. The spindle, around whose center the arm plate revolves is so arranged as

to be between the pin to which the up and down rod is attached and the semaphore arm. The force of gravity acting on the counter weight pulls down on the up and down rod, which in turn transmits this pull to the end of the arm plate to which it is attached, and consequently raises *up* the end to which the blade is attached, thereby always tending to bring the blade into the horizontal position.

Fig. 49 shows a front and side view of a high home signal.

The Fig. shows a one-bladed signal. In a two or three-bladed signal the upper length of pipe in the pole is extended, and the additional arm plate bearings, arm plates and blades are attached as is done with the one-bladed signal. The "L" crank is made in two or three "ways," and an additional up and down rod is put on for each blade. The lowest blade should be 25 ft. from the top of the foundation, and other blades are spaced 6 ft. 6 in. therefrom and from each other.

Fig. 50 shows a front and side view of a typical pipe connected dwarf signal. The ladder is, of course, unnecessary with these as they are generally less than three feet high. Neither is it necessary to guide the up and down rod. In other essential particulars they are much the same as the high signals.

In Figs. 49 and 50 the signals shown are of the two position type, 60 degrees downward inclination.

A three-position, either lower or upper quadrant signal, is made by applying an arm plate bearing and arm plate of a slightly different design. The other fittings remain the same. The reader should note that there are three holes for glass in the arm plate illustrated for the high signal, and two in the arm plate illustrated for the dwarf. The reason for this will be explained fully when we come to night indications.

The pipe line leading from the lever in the

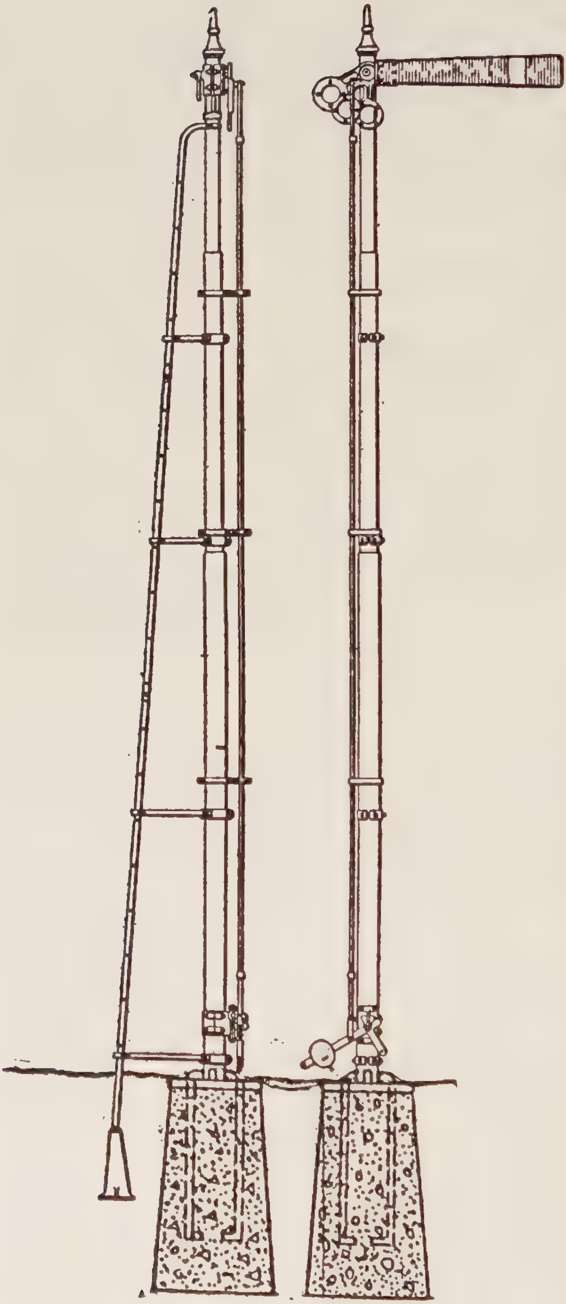


Fig. 49.

tower is led up to the signal and attached by a jaw to the short arm of the "L" crank. It is good practice to use a screw jaw for this connection, as it is often convenient to lengthen or shorten the pipe line a little at the base of the signal.

We will now return to switch movements for a moment, and explain the use of bolt locks to which we have referred.

In England these devices are called "detectors," which is perhaps a more explanatory title than that of bolt lock.

Their object is to prevent the leverman from

clearing a signal if the switch which it governs has failed to respond to the movement of its lever. For instance, we will suppose that the pipe line operating a switch several hundred feet away from the tower has broken close to its connection with the switch. The leverman reverses his lever and the drag of the pipe line is heavy enough to prevent his detecting that the switch has failed to respond to the lever movement. He might then reverse his facing point lock lever and

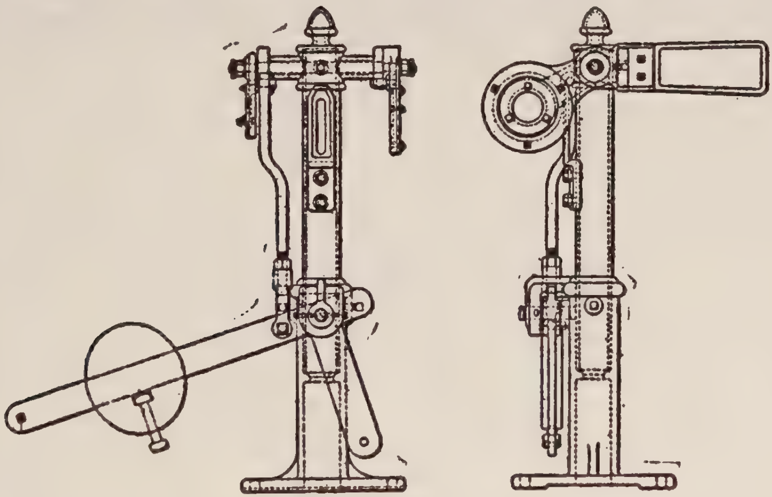


Fig. 50.

the plunger would enter the hole in the lock rod for the switch in its normal position and he would still fail to discover that the switch had not moved. He could then clear his signal, thereby giving wrong and perhaps dangerous information to the engineman of an approaching train. Where a bolt lock is used, this cannot be, as will now be shown.

The bolt lock Fig. 51 consists of two rectangular bars of iron, free to move longitudinally in a cast iron frame, and so placed that they cross each other at right angles, with the center line of one a little above that of the other. Each of these bars has a notch about half its width cut in one of its edges. One of them is

attached to the switch points, usually to the point lug on the side nearest the pipe line to the signal and is called the switch bar, and the other is cut into the pipe line which operates the signal itself, and is called the signal bar. The switch bar, of course, moves backward and forward as the switch is thrown, just as has already been described for the lock rod, *provided,* and here is the essential point, that the notch in the signal bar is in the same vertical plane in which it, the switch bar, travels. The signal bar too can only make its

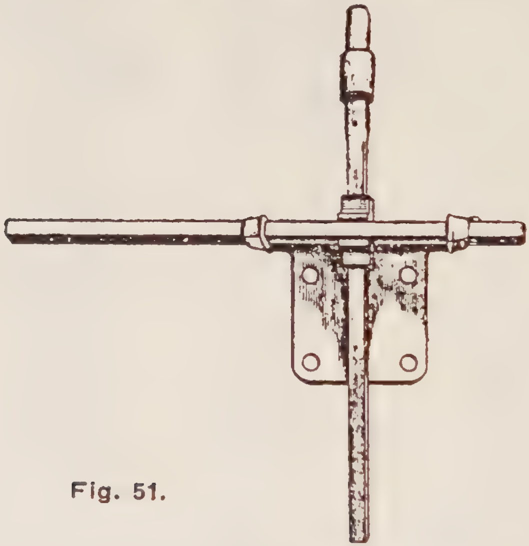


Fig. 51.

travel when the notch in the switch bar is in the same vertical plane in which it travels. With the signal normal (in the stop position) the signal bar is so placed that its notch will allow free movement to the switch bar.

In the case we have just cited, however, the notch in the switch bar would not move into the same vertical plane in which the signal bar moves until the switch had been reversed, and the signal could not, therefore, be cleared because the edge of the notch in the signal bar would strike against the unnotched side of the switch bar. Therefore, if the switch had failed

to move when its lever was reversed, the signal could not be cleared, because its pipe line would be prevented from moving by the bolt lock and the leverman failing in his efforts to reverse the signal lever would be warned that the switch had not moved.

Next to the interlocking of the levers in the machine, this device is probably the greatest safeguard in the construction of a mechanical interlocking plant, and every high speed facing point switch should be bolt locked with every signal controlling the route over it. Bolt locks are made in one, two or three "ways," so that a switch may lock one signal in its normal position, and another one or two in its reversed position, or vice versa.

Fig. 52 shows a wire connected high signal. It will be noted that instead of the "L" crank a *tandem chain wheel* is attached to the foot of the pole.

The two wires from the lever have pieces of one-quarter inch straight link chain let into them, which are passed around these chain wheels. From the other end of the chains the wires are continued and connect to a *balance lever* placed more than half way up the pole.

On one end of this balance lever is a counter weight, and a short up and down rod connects it to the arm plate. When the lever in the tower is reversed the wire connected to the end of the balance lever farthest away from the counter weight is pulled on, while the other is slacked away. This raises the counter weight, shoves up on the up and down rod, and brings the signal blade to the clear position. When the lever is returned to normal the other wire is pulled on, while the first one mentioned is slacked away, pulling down the counter weight and raising the blade to its normal position. It is intended that the counter weight should be heavy enough to restore the blade to normal, unassisted, but it has been found to be much better to also

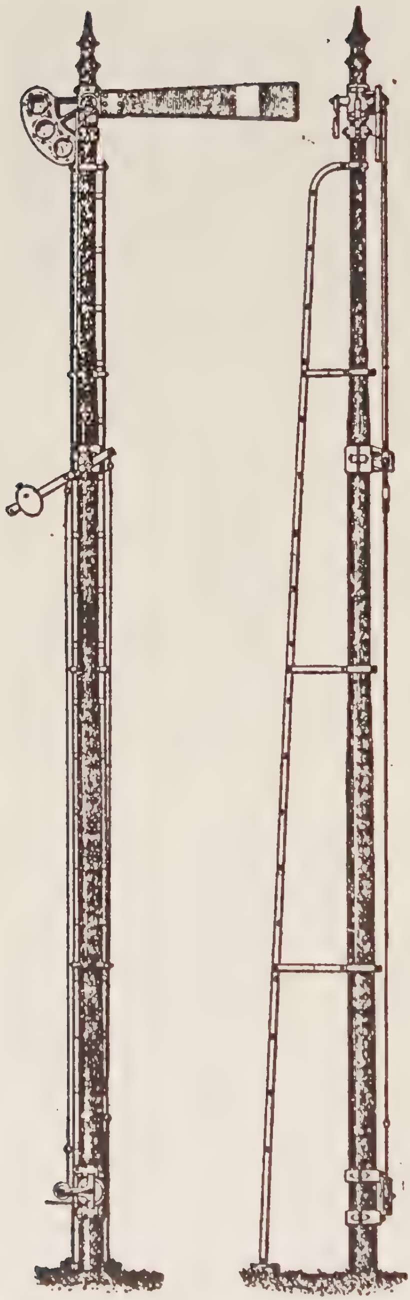


Fig. 52.

have a pull on the balance lever, hence the second wire has been introduced. In early installations in this country, only one wire was used, and the signal was returned to normal by the counter weight alone, but there is too much chance of a kink in the wire catching in a wire pulley and holding the signal at clear for this method to be continued as good practice.

In England one wire only is used at the present time, but there a small, very flexible wire cable is used instead of the hard drawn steel wire used in America, and the chances of its kinking are not so great.

Fig. 53 shows a very common type of wire connected dwarf signal. Here the pull-to-clear wire is carried around a horizontal chain wheel and then to the end of the *operating shaft,* while the wire from the tail lever in the tower is attached directly to the end of the operating shaft. When the lever is reversed the operating

shaft is pulled towards the right of the figure compressing the coil spring which is wound around it. A projection from the end of the operating shaft engages the escapement crank, which shoves up on the up and down rod and clears the signal blade. The spring in this type takes the place of the counter weight in the high signal.

Bolt locks may be used with wire connected signals as with pipe connected. The signal bar in a wire bolt

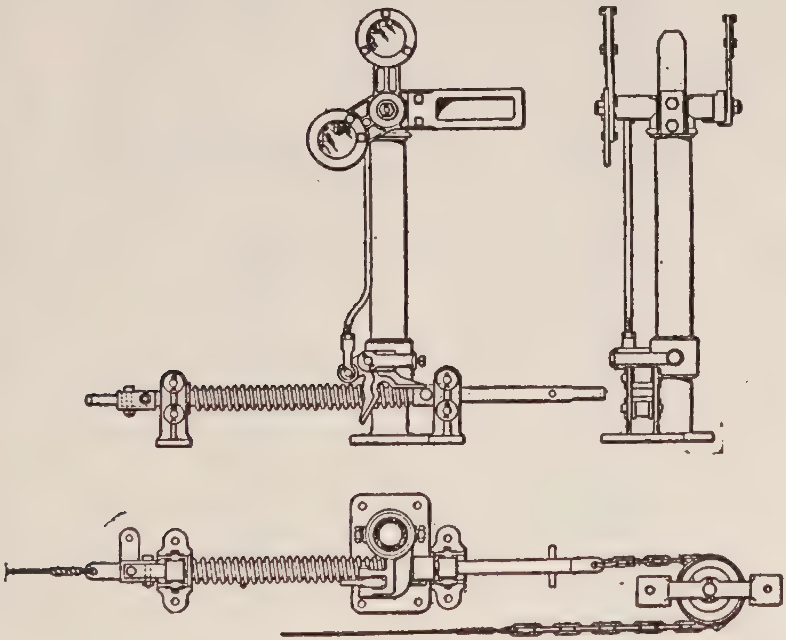


Fig. 53.

lock is equipped with shackles on each end, instead of tangs. Where a bolt lock is cut in to a wire line, it should always be in the wire which pulls the signal to clear.

I will digress here a moment to say that amongst signal men the wire which pulls the signal to clear is usually called the front wire, and the one which pulls it to normal, the back wire. This nomenclature is a lit-

tle confusing to a beginner, because the front wire is attached to what in the machine is the back of the lever, and the back wire to the front of the lever. I avoided the use of the terms front and back wire in the foregoing description just for that reason, but hereafter when I have occasion to mention these wires I will call them front and back in the sense just explained.

Wire adjusting screws should be let into both the front and back wires near the signal, either high or dwarf, in addition to those in the tower.

In the foregoing description I have purposely omitted reference to bracket signals. I shall now say a few words on that subject. The attachments, or as they are generally called, "fittings" for bracket signals do not differ greatly from those already described. With pipe connected signals the "L" cranks are placed at the base of the pole. The up and down rods are run up the pole to the bracket where they are pinned by jaws to right angle cranks which connect by horizontal pipe lines to other right-angle cranks at the base of the "masts" which again turn the direction of the pipe to vertical and connect to the arm plate.

With wire connected signals a tandem chain wheel is placed at the bracket and the wires connect to a balance lever, the end of which is made like a three way crank. Another tandem chain wheel is placed at the base of the pole.

Fig. 54 shows a pipe and Fig. 55 a wire connected bracket signal from which the reader will easily see at a glance how the connections are made. The main poles of bracket signals are not infrequently made by a lattice method of construction and not of large pipe. The masts, however, are always made of pipe.

I shall now describe another device, which, although it is not used to any great extent in modern signal practice, and should certainly be avoided in new work

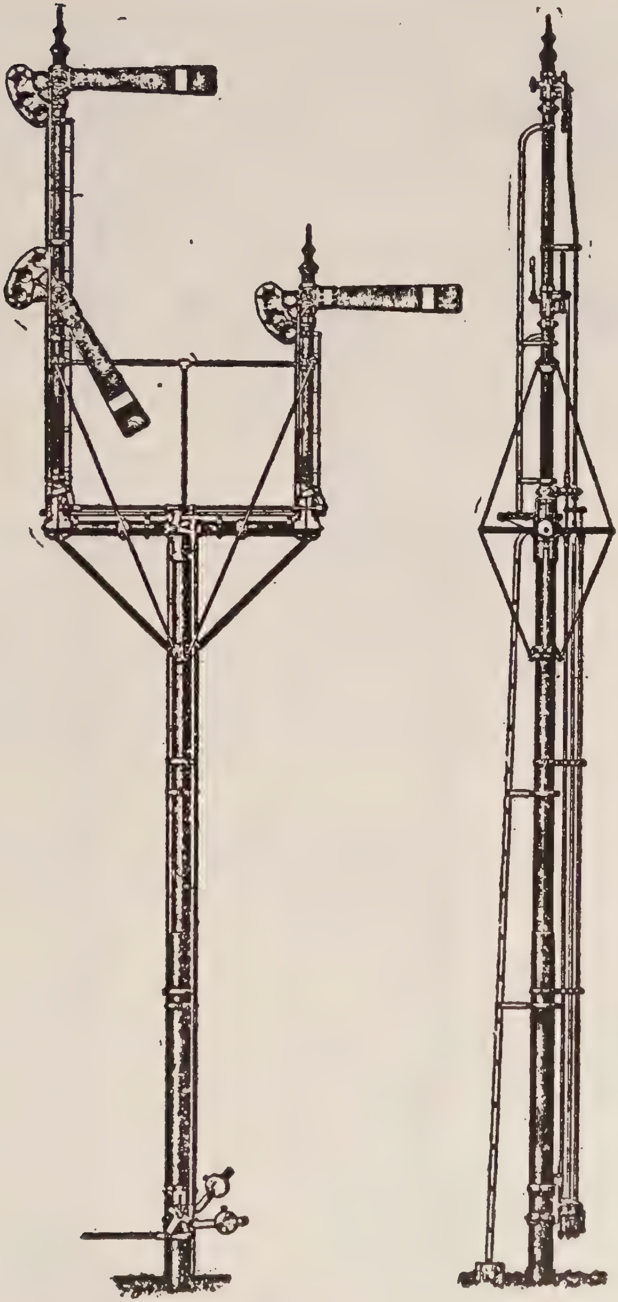


Fig. 54.

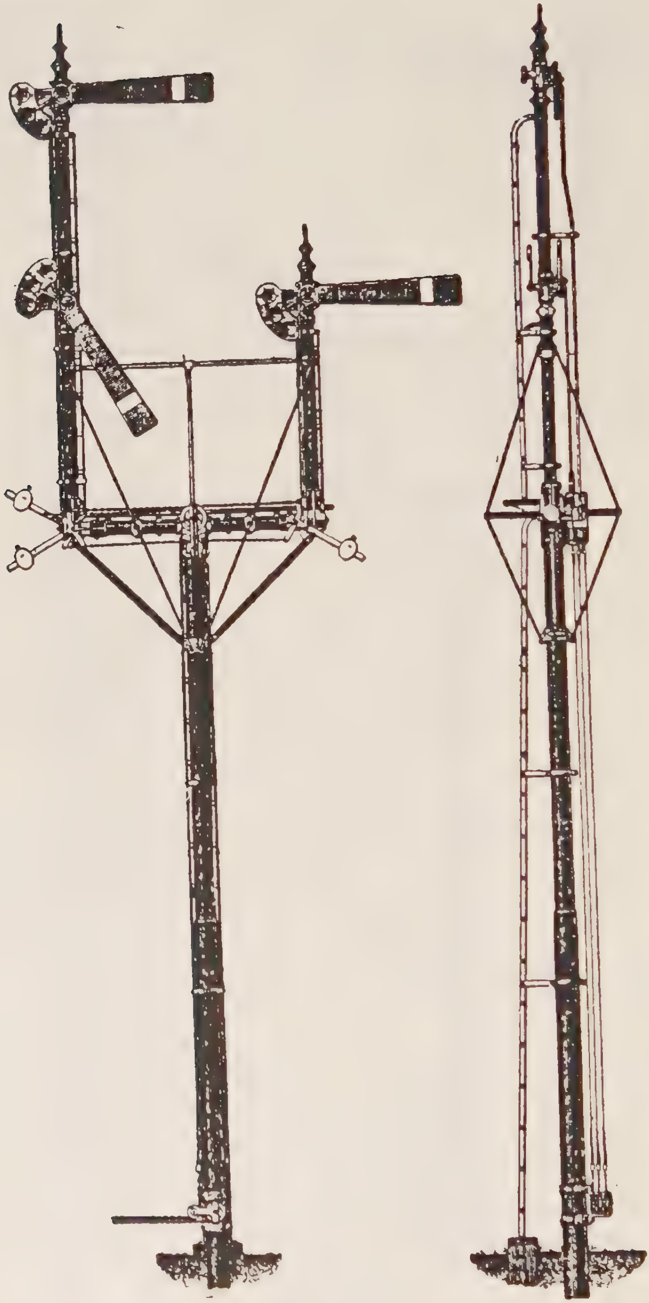


Fig. 55.

as much as possible, is a very handy device at times where old plants are to be enlarged. It is known as a *selector.* By its use one lever may be made to throw one, two, three, or even four signal blades, each independently of the other. A switch must, however, enter into the combination.

We will take the case of a two-arm pipe connected home signal governing the two routes at a junction. The pipe line from one lever in the machine would be led up to the selector, which is placed near the signal. If the switch is normal the pipe line will be attached

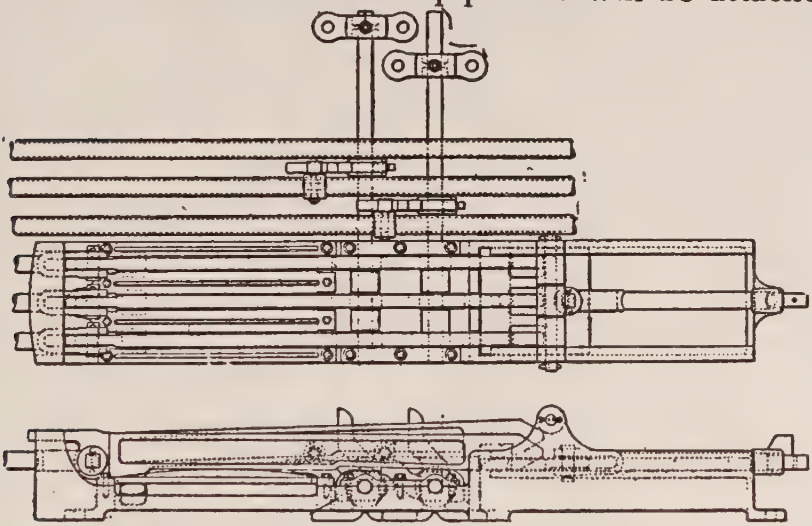


Fig. 56.

through the selector to one signal arm, but if the switch is reversed the pipe line will be detached from that arm and attached to the other. The switch *selects* its signal, hence the name.

Fig. 56 shows a common design of three way, or as it is more often called, three *hook* selector, in which escapement cranks are rigidly fastened to rods. These escapement cranks are operated by lugs attached to the pipe line by which the switches which do the selecting are moved. As either of these pipe lines

move it also moves the escapement crank, which in turn revolves the rod to which it is attached. This rod also has a cam attached to it, which as it revolves, either lowers or raises one of the hinged hooks, shown in the Fig. When down these hooks engage

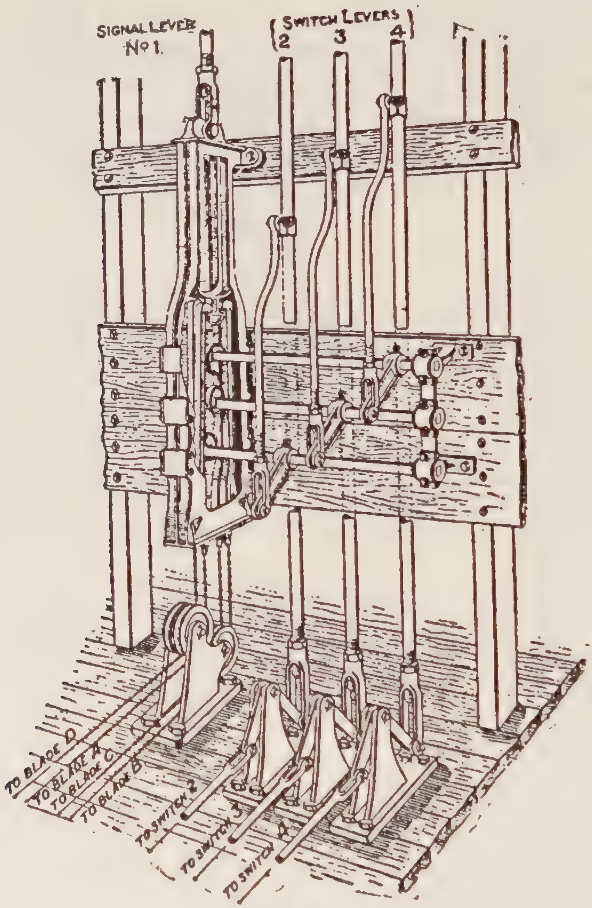


Fig. 57.

the slide, which by its tanged end is fastened to the pipe line leading from the signal lever. A movement of this pipe line, therefore, moves any one of the three pipe lines whose hook happens to be down at the time. Each of the three is attached to a different signal

blade, so that as before explained the position of the switch selects the signal which the lever will operate.

One serious trouble with pipe selectors is that ice and snow sometimes pack in to them so that the hooks cannot drop down and hold in the slide.

Pipe selectors should be placed near the signal so as to save as much pipe line as possible.

The most favored type of wire selector is the tower type, shown in Fig. 57. With this separate wire lines of one wire each are run from the signals to the tower, and the selector is placed in its lower story.

Only one back wire is used which is attached to the tail lever of the signal lever. The balance lever on the signal pole is made in as many ways as there are signal blades to operate. A short chain is passed through a loose pulley, with a hook on the end to which the back wire is attached, and the two ends of the chain are fastened to the outside and inside balance levers, after being looped through large shackles on the intermediate balance levers. When the signal lever is reversed the back wire is slacked away and the balance lever which is pulled down by the front wire pulls up enough slack chain through the movable pulley in completing its stroke, to draw the back wire fairly taut. When the signal lever is returned to normal and the back wire pulled on, it will draw down enough on the balance lever to insure, being aided by the counter weight, that the signal blade is returned to normal. The tower ends of the front wires are attached to the lower ends of the selector hooks.

The movements of the switch levers revolve the short rocking shafts or bars to which they are attached which carry the cams with them and engage or disengage the proper selector hooks to or from the slide plate, which is attached to the back of the signal lever much the same as already described for the pipe selector. The whole device being inside the

tower is not subject to interference from ice and snow as is the case with a pipe selector. As this type stands vertically in the tower the force of gravity cannot be depended on to drop the hooks into place. Their lower ends are so shaped that the weight of the front wire which they support tends always to draw the hook end in toward the slide.

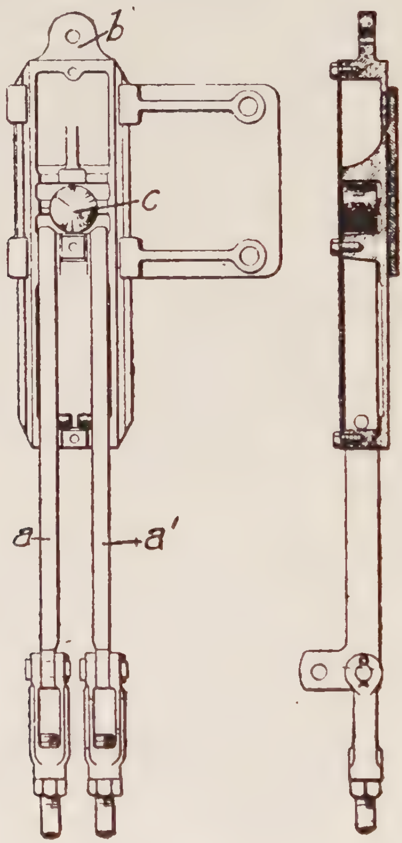


Fig. 58.

Another device which is the opposite of a selector is the *mechanical slot*. Its use makes it necessary for two levers to be reversed in order to clear one signal. It is very little used at present on complete interlocking plants for reasons which will appear later when

we come to the consideration of power distant signals, but is a device which may be made very useful where switches which are operated by ordinary switch stands are bolt locked with a signal. This will be taken up in its proper place.

Where mechanical slots are used with complete interlocking plants, it is when two plants are so near each other that one distant signal will suffice for both. the action of the device being so that if leverman at A sets the switches, derails and home signal for a route and reverses his distant signal lever the blade will not respond thereto unless leverman at B has also set his switches, derails and home signal and reversed his distant signal lever.

Fig. 58 shows one design of mechanical slot. It is generally attached to the signal pole above the balance lever. The balance lever is a two way, and the levers are attached to the *vertical slides,* shown as a a′ in the figure. The slot slide b is attached to the arm plate of the signal blade by a short up and down rod. When A reverses his lever vertical slide a moves upward past roller c, shoving it, the roller, to one side and does not move the slot slide or signal blade.

If, however, after A has reversed his lever, B should reverse his, roller c cannot move out of the way of vertical slide a′ to which B's lever is attached. Consequently the vertical slide shoves up on the roller and through it on the slot slide and arm plate, thereby clearing the signal. If B should reverse his lever first the action of the slot would simply be reversed, and the signal arm would not be moved until A had reversed his lever.

With both A's and B's levers reversed and the signal blade clear, if either sets his lever normal again, roller c will either roll away sideways from on top of the slide which has shoved the signal to clear, or if the lever controlling that slide is the first one to be

reversed, it will simply follow the end of that slide downward by the force of gravity. In either case it will drop away from the top of the slot slide, which being a fairly heavy casting, acts as a counter weight and pulls down on the arm plate, restoring the signal to the normal position.

CHAPTER IX.

DERAILS—GENERAL REMARKS ON MECHANICAL INTERLOCKING.

In the foregoing description of mechanical operating and locking devices and lead outs, I have aimed as much as possible to avoid confusing the reader with references to special devices until the fundamental principles were made clear, and to that end have made but one allusion to derails so far. I will now say a few words on that head.

As a general question, a derail movement is the same as that for a switch, either a facing point lock or a switch and lock movement, but they differ from switch movements in one or two minor details.

Derails may be grouped under three general heads:

(1) Split point derails.

(2) Wharton derails.

(3) Solid derails.

Fig. 59 shows 1 and 3, and Fig. 60 shows 2.

As there is no head rod to the split point, and solid type, a special switch adjustment such as has been described for switch movements cannot be applied. Neither can we use a front rod.

I have found it very convenient, in lieu of a special switch adjustment to use what the dealers list as a *gain stroke jaw,* although it might more properly be called a "loose stroke jaw." This is shown in Fig. 61. Its action is the same as that of a special switch adjust-

ment. It may either be attached to the arm of the crank which throws the derail, or to the derail itself, with a facing point lock, or to the arm of the escape-

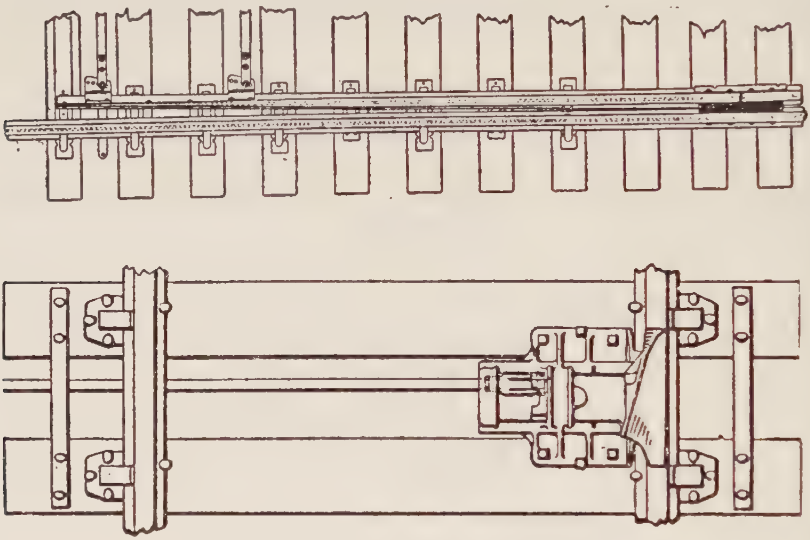


Fig. 59.

ment crank, or to the derail itself with a switch and lock movement.

With the Wharton tvpe of derail, a special switch adjustment may be used.

With the split point and Wharton types, one point lug is bolted to the point, and a lock rod shorter than that used where attached to the middle of the front rod, is connected thereto.

With the solid type, a lug to which the lock rod may be attached, is usually made a part of the derail.

Fig. 61 shows a sectional view of each of the three types already illustrated, with gain stroke jaw or special adjustment attached to each.

Torpedo machines are sometimes used in lieu of derails, and sometimes as an adjunct thereto. These devices are arranged so that when the lever by which they

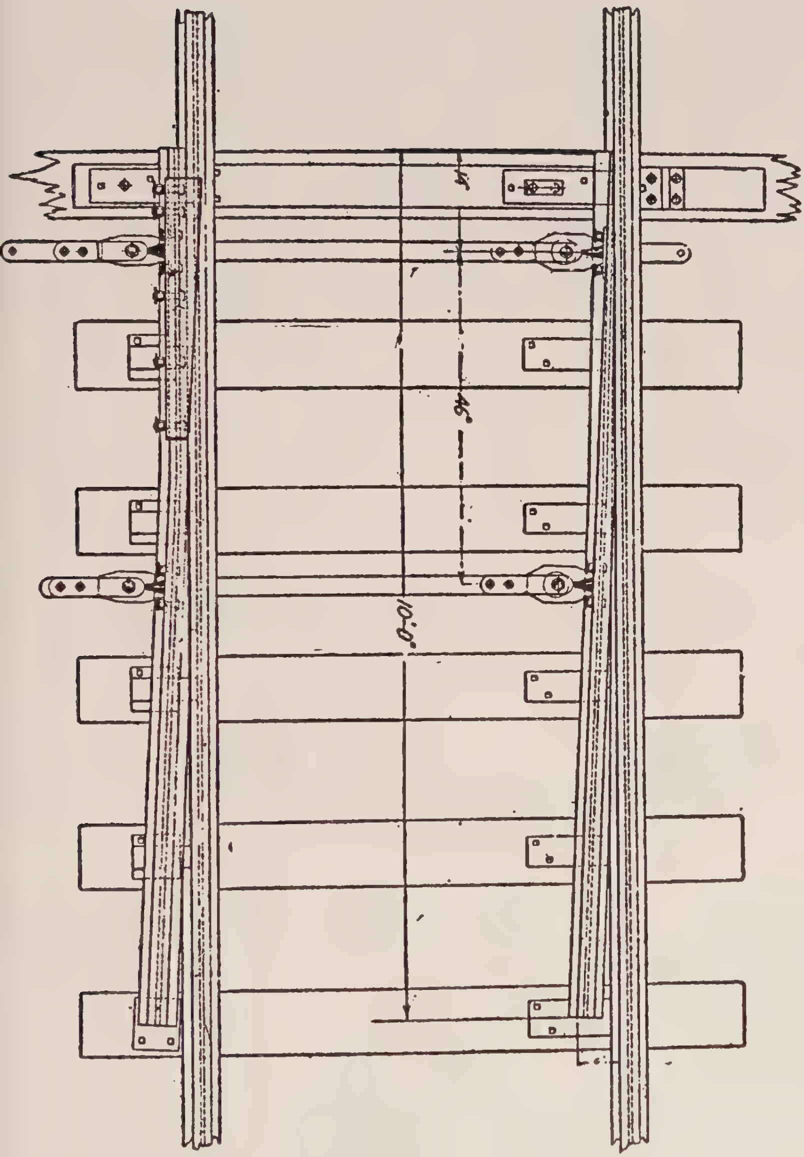


Fig. 60.

are operated in the machine is set normal a movable arm carrying a detonating torpedo pushes the torpedo on top of the rail, where it explodes as soon as a wheel passes over it, warning an engineman of danger ahead. Where used they should be placed at the distant signal, so that an engineman will have time to stop his train before over-running the home signal, if his engine should explode one. As an adjunct to derails in particularly dangerous places, their use may be of value. As a substitute, however, it is not be recommended, and is generally forbidden by State Authori-

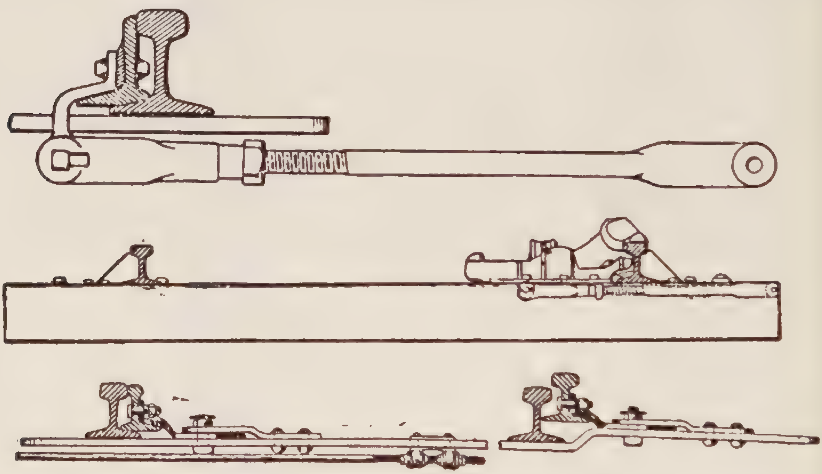


Fig. 61.

ties. As the magazines of these devices carry only a limited number of torpedoes they require constant attention and recharging.

Interlocking plants are frequently used to protect the approach to drawbridges, so that, in case the draw is open to allow for the passage of a vessel, trains will be thrown from the track by a derail, or diverted to some track which does not lead onto the bridge, to prevent their running into the open draw. Several accidents entailing appalling loss of life having happened through lack of proper interlocking.

As a general thing the interlocking machine is placed on the draw itself, although sometimes on one shore or the other; in either case some or all of the pipe lines leading to the derails and signals must be carried across the bridge, and must be so arranged that that portion of them which is permanently attached to the bridge may be disconnected from that portion which is permanently placed on shore, whenever the draw is to be opened. This is done by using a *bridge coupler,* one of which is illustrated in Fig. 62.

The pipe lines which are to go off the draw are attached to jaws with rectangular slots in their ends, shown as a a′ a″ a‴. These slots when the jaws are down pass over hooks b b′ b″ b‴ in the other half of the coupler, thus connecting the two portions of the pipe lines.

Another pipe line shown as c is attached to the side of the frame of the coupler, shown as d, so that when the lever to which this pipe is attached is reversed, the frame carrying with it the slotted jaws will be raised, as shown in the side view, and all of the pipes detached at once from their corresponding extensions. The draw may then be opened and when it is returned to its normal position the coupler may be dropped and the pipes thus connected again.

On a railroad drawbridge the end rails are often made so that they may be raised before the bridge is swung, and where this is the case *bridge locks* are applied. The general principle on which these operate is exactly that of a facing point lock and no further description will be given here.

So far, as before stated, I have endeavored to bring only such matter into the description as was necessary to give the reader a general idea of the subject. There are, nevertheless, a few general questions which had better be explained before leaving this part of our subject.

In describing jaws, both solid and screw, pipe lugs, etc., I have spoken exclusively of those with tanged ends. Each of these parts is also made with a stub end, so that it may be welded to a bar of iron instead of being attached to a pipe. As explained earlier, where any considerable amount of offset has to be made in a pipe line, a bar of solid iron should be let into it, and the offset made in that. If it is convenient to weld a jaw on one end, a stub end jaw should be used, as it is a little cheaper. Some signal men will

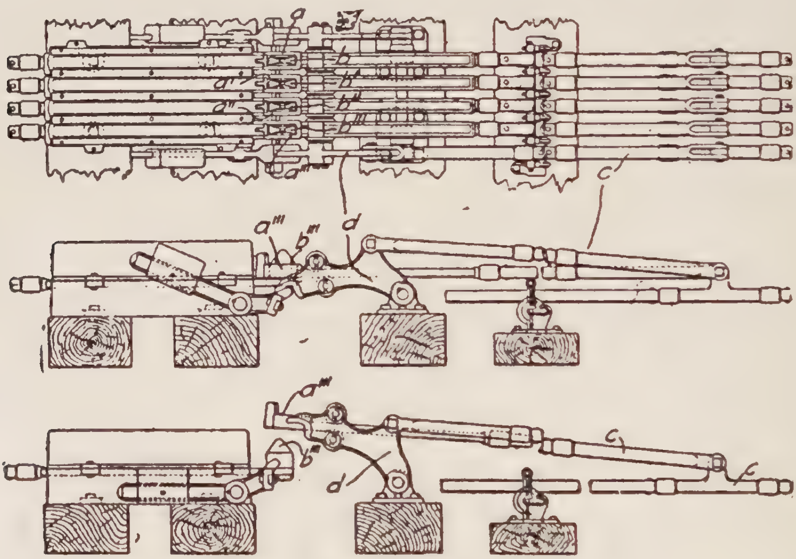


Fig. 62.

cut the tang end off a solid jaw and throw it away so as to get a stub end jaw, which is wasteful, and, therefore, bad practice. All types of jaws used with one inch pipe may be had of dealers, with their ends tanged to fit three-quarter inch pipe which is used for signal up and down rods, and correspondingly the small jaws using a five-eighths instead of a seven-eighths pin, used for up and down rods, may be had with ends tanged for one inch pipe. The pipe, it should be understood, is measured by its inside diameter.

Links may be had with solid jaws on each end, or with a screw jaw on one end. The latter will be found the more convenient.

Besides the jaws already mentioned there is a *wide jaw* and a *double jaw.* The former is intended to fit on over an ordinary jaw, with one pin holding both of them to a crank arm, for instance, where the pipe line is carried on past the crank. Double jaws are like two ordinary jaws, with the jaw ends joined, and are used for the same purpose. Each is shown in Fig. 63. They are not used a great deal, most signal engineers preferring to let a lug into the line and connect that to the crank arm with a link.

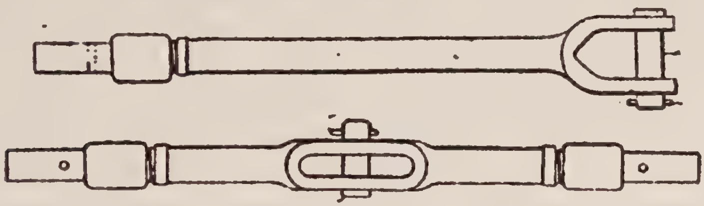


Fig. 63.

Where interlocking pipes are carried across bridges, through tunnels or on elevated structures, lateral space is often very restricted. Compensators, both straight arm and lazy jack, are furnished, which are built so that they stand vertically and take up very little width.

Compensation on swing drawbridges is a vexatious problem. The draw itself being made of iron or steel, expands and contracts. If the machine is on the middle of the draw, as it generally is, the pipe lines are held fast there, and as this is the pivot of the draw, they, together with the draw itself, expand or contract toward or away from the free ends. The half of the bridge coupler which is on shore being attached to the ground or the bridge abutment remains stationary, and if the half which is on the draw moves with it, a very moderate change in temperature, if the draw is a long one, will cause enough movement in the free

ends of the draw to prevent the slotted jaws in the coupler from engaging the hooks.

The only satisfactory solution of this problem I have yet found is to lay a heavy plank, wide enough to carry the bridge coupler and compensators, the entire length of the draw, to whose centre it should be rigidly fastened, but free at the ends. The compensator and bridge couplers should be bolted to this plank; which, of course, if the draw is at all a long one, is made by splicing several shorter planks together at the ends. As wood does not expand and contract as iron and steel do, this fixes the coupler in a permanent location with reference to its other half on the shore side, and to the machine. The compensators take up the expansion and contraction of the pipe itself just as if the whole arrangement was on solid ground. The long plank may be guided and held from moving sideways by iron stirrups attached to the bridge itself and fitted around the plank loosely enough to allow the bridge to expand and contract without pulling on the plank.

To guard against unnecessary damage caused by derailments at interlocking plants, which may occur especially at derails, the main pipe lines should be kept some little distance from the track.

Where there is room the nearest pipe should not be closer than four feet to the nearest rail where the pipe lines parallel a track, and a greater distance than this is desirable if the topographical conditions permit.

Care should always be taken that "cross pipes," pipes crossing the track, are supported at least every seven feet, either by transverse pipe carriers, or by setting foundations, with tops and ordinary carriers, between tracks which are some distance apart. Where two parallel tracks are fourteen feet apart, center to center, which is a very common distance, and eight

feet ties are used, transverse pipe carriers should be placed six inches from each end of the two ties between which the pipes pass in each track. With wider centers it is better to set a foundation and ordinary pipe carriers midway between the tracks.

Signal engineers cannot be too rigid in insisting that the Maintenance of Way Department shall provide the very best drainage at interlocking plants. Water standing around detector bars and then freezing will soon completely tie up a plant.

Sometimes in very close quarters around yards and large stations, it is necessary to place the plunger castings for facing point locks between the rails of a track, in which case the front rod does duty also as a lock rod. It is made flat and the holes for the plunger are drilled in it. This practice, however, should be avoided wherever possible.

On new fills likely to settle considerably, or to slide out, it is good practice as a temporary expedient to fasten the pipe carriers, and even the cranks and compensators, to the ends of long ties placed every seven feet for the pipe carriers; three ties together for the compensators, and two for the cranks. As soon as the fill is well settled, however, concrete or cast iron foundations should be put in and the ties dispensed with.

Compensators should be set in the position they occupy with the lever in mid stroke, after which the arms should be spaced in accordance with the temperature tables which have been recommended by the Railway Signal Association.

Railroads which handle large quantities of packing-house products find that the brine which is constantly dripping from refrigerator cars is very destructive to pipe lines. Some relief from this may be had by using galvanized pipe for cross pipes. Some signal engineers use it for all piping, but

my experience has not led me to believe that its use in main pipe lines is of enough advantage to justify the additional expense. Where black pipe is used the pipe lines should be kept well painted with good mineral or graphite paint.

It not infrequently occurs that pipe lines have to be carried under ground, as for instance, where they cross a paved street. In such cases the one inch signal pipe is frequently run through a two inch galvanized pipe with a stuffing box to fit the one inch pipe screwed on each end. The two inch pipe is then filled with some non-freezable oil.

Wires too are often run through one-half inch galvanized pipe filled with oil, with a stuffing box to fit the wire screwed on its ends.

If a turn in a pipe line has to be made under ground, cranks fitted into cast iron water-tight boxes bushed to take a two inch pipe where the jaws enter are used. These boxes are filled with oil as well as the pipe.

Even with the best construction a certain amount of friction is present in every pipe and wire line, and this, of course, increases with the length of the line, so that a point will eventually be reached at which the power exerted on the lever by the leverman will be entirely expended in overcoming this resistance. Besides this pins, jaws and the holes in crank and compensator arms are continually wearing, so that no line can be considered as entirely free from lost motion. It has, therefore, been found advisable to limit the "reach" of a mechanical interlocking plant. In England railroads are forbidden by law to operate facing point switches further away from the machine than two hundred yards, six hundred feet, or trailing point switches further than three hundred yards, or nine hundred feet.

In America we have very few switches which are

not used as facing points, at least occasionally. A few railroads with very heavy traffic and four or more tracks, rarely reverse the current, but so much of our mileage is single track and so many of our double track railroads reverse traffic occasionally, that I believe the foregoing statement is correct.

It is, therefore, well for American signal engineers to keep nearer to six hundred than to nine hundred feet as the maximum distance a switch should be away from the lever that operates it. I have found seven hundred feet to be a very satisfactory maximum, except in rare cases where the pipe line can be run out without any turns. Some signal engineers, however, will go much further than this, and there is no general rule in American practice, as there is in British.

In the opening article of this work I said that the conventional signs used by signal draftsmen would be illustrated and explained as the necessity for so doing developed.

Fig. 64 shows a track, a crossing, an interlocking tower, two switches and three derails. The reader should note that one of the switches is shaded in, while the other is not. The shading is the conventional method of showing that the switch is included in the interlocking. The unshaded switch is not operated from the interlocking machine. The line next the rail in front of the shaded switch represents the detector bar. Detector bars are also shown for the three derails. The numbers in the circles denote the numbers of the levers in the interlocking machine by which the signal, switch, derail or lock near which the circle is drawn is operated. Derail No. 4 is a split point derail; No. 7 is a Wharton, and the derail with the line from No. 5 is a solid derail. The lines connecting this last derail and the switch with the figure 5 denote that lever five throws both the switch

and the derail simultaneously; lever No. 6 also locks them both. The letters F. P. L. after the figure 6 show that this is a facing point lock. The letters S and L at Nos. 4 and 7 show that these derails are operated by switch and lock movements. The straight

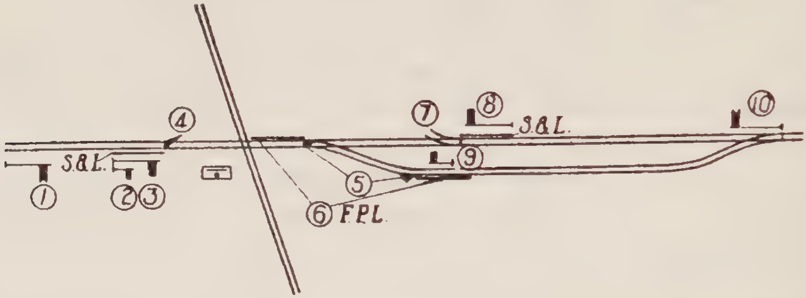


Fig. 64.

line in the tower represents the machine, and the dot the leverman. This shows at a glance which way the machine is to be set. The home, distant and dwarf signals shown have already been explained.

CHAPTER X.

POWER INTERLOCKING.

Before taking up the subject of power interlocking, I shall state a few more electrical principles, an understanding of which is necessary to a thorough comprehension of the subject.

As before, I shall state these merely as facts, and shall not take space or the reader's time to go into an explanation which more properly belongs to a treatise on electricity and magnetism.

(1) When two plates which form an electric couple are submerged in an electrolyte in which they do not touch each other, so as to form an electric cell, as already described, it is known as a primary cell.

(2) A gravity cell is a primary cell in which the electric couple is a copper plate and a zinc plate. The copper plate is placed at the bottom of the jar and the zinc plate, often shaped into a ring, is suspended part way up the jar. The electrolyte is a solution of copper sulphate, better known perhaps by its trade name of blue vitriol.

(3) A gravity cell must be so placed that a current is flowing through and from it the greater part of the time. That is, it must be used on work where the circuit is almost always closed and only broken intermittently; otherwise a chemical action takes place in the electrolyte which destroys the capacity of the cell to generate an electric current.

(4) A gravity cell must be cleaned and refilled

every four or five weeks whether it is being drained fast or slowly, and it may be worked to its full capacity without shortening its life.

(5) A primary cell whose electric couple is copper oxide and zinc, and whose electrolyte is a solution of caustic soda is known under the general head of a Lalande cell.

There are many of these on the market, as the Edison, the Schoenmehl, the BSCO, the Gordon, the Banks, etc., etc., differing from each other in their mode of construction.

(6) Lalande cells do not lose their efficiency when not generating current. They may be used, therefore, on open circuit work. Each cell, however, has a limited output. This output may be taken away slowly, in which case the cell will last a long time, or it may be exhausted very quickly.

(7) A dynamo or electric generator is a machine which when its movable part is revolved rapidly will produce an electric current just as a battery will.

(8) An electric motor is a machine much like a dynamo, the movable part of which, when an electric current is supplied to it, will revolve and may be made to do work just like a steam engine.

(9) If the direction of the motion of the movable part of an electric motor is reversed the motor becomes a generator and produces an electric current.

While running as a motor, too, what is known as the counter electro motive force is being generated by a motor. By making proper connections, an electric current may be produced by this counter electro motive force, which as will appear presently, may be used to advantage.

(10) A storage cell is a cell, the plates of which are made of lead; one nearly pure and the other chemically prepared (peroxide of lead), and the

electrolyte of which is dilute sulphuric acid (oil of vitriol). When the plates are submerged in the electrolyte and externally connected together, no current is generated, but if a current from some other source is fed into the plates they will retain it and send it forth again just as a primary cell does. A collection of storage cells is called a storage battery or accumulator.

(11) If a dynamo is used to charge a storage battery enough electricity can be stored in one day to last several days, thereby saving the expense of operating the dynamo more than a small portion of the time.

(12) Nobody knows in which direction an electric current flows, but for the sake of having a uniform practice it is assumed that with primary cells it flows from the copper plate along the connecting wire or conductor, as it is called, to the zinc plate. The connection of the conductor to the copper plate is called the positive pole, and the connection of the conductor to the zinc plate is called the negative pole.

In a storage battery when it is charged, the positive plate is formed of peroxide of lead, while the negative plate is almost pure lead.

The chemical action which takes place while the battery discharges, alters the composition of the plates, and they both become a lead compound in which sulphur appears.

As the battery is recharged the condition of the plates again changes through the chemical action in the cells, until they become again as at the start, peroxide of lead for the positive and pure or nearly pure lead for the negative.

(13) Electric currents may be converted into mechanical power by means of electro magnets as already explained, and some currents may be able

to produce more mechanical power than others, just as a steam engine with a pressure of two hundred pounds per square inch in its boiler will give a stronger pull on the piston rod, with the same sized cylinder, than if it had a pressure of only seventy-five or one hundred pounds per square inch. The power of a battery is measured in volts. It is immaterial for present purposes that the reader should be given a complete definition of the volt. Suffice it to say that it is the unit or gauge by which the ability to produce mechanical power in a cell is measured, just as we measure the power of steam in a boiler by pounds per square inch.

(14) The amount of current that flows from a cell is measured in amperes. The ampere does not depend on the voltage of the cell any more than the amount of steam let out of a boiler depends on the pressure in the boiler. We may have a boiler with fifty pounds pressure per square inch, with a large pipe leading from it through which ten cubic feet of steam passes in a second, and we may have a boiler with a steam pressure of two hundred pounds per square inch with a very small pipe leading from it through which only five cubic feet of steam passes in a second. Just so we may have a cell with an electric pressure of one hundred volts from which we are drawing a current of one-tenth of an ampere per minute, or we may have a cell with an electric pressure of two volts from which we may draw a current of one ampere a minute.

(15) Storage cells and Lalande cells can give forth a certain amount of current, and when that is gone they are exhausted. They are usually rated by "ampere hours." A cell of one hundred ampere hours is designed to give forth a current of one ampere continuously for one hundred hours,

or of one hundred amperes for one hour, or of six thousand amperes for one minute.

This last statement is more theoretical than actual. In all cells there is a resistance between the two plates inside the cell known as the internal resistance which prevents a cell from being exhausted instantaneously, no matter how little resistance there is in the external circuit.

The current may be drawn off continuously until the cell is exhausted or it may be drawn off intermittently so that the cell may last months or even years before it is completely drained.

(16) Gravity cells do not give forth a limited amount of current, but, as before stated, they have to be cleaned and refilled about once a month. They can be worked to their full output all the time, if properly cared for that often.

(17) Some substances allow electric currents to pass through them more easily than others. Such materials are said to have low resistances. Silver, copper and iron have low resistances. Glass and rubber have high resistances. The resistance of any conductor is proportional to its length. That is, if one foot of silver wire offers a certain amount of resistance, two feet of the same wire will offer just twice as much, and so on. Volume for volume silver offers much less resistance than iron, yet several miles of silver wire may offer more resistance than a few inches of an iron wire of the same diameter. The larger the section of a conductor the less resistance it will offer for a given length.

(18) Where a small amount of current is all that is required to do the work desired, it should be drawn from the cell by a conductor offering considerable resistance. If the resistance is decreased, more current, measured in amperes, will flow. A conductor may be likened to a pipe opening into a

steam boiler, and the resistance of the conductor to the diameter of the pipe. A pipe of large diameter would draw off a large quantity of steam in a given time; a conductor of low resistance would draw off a large quantity of electric current in a given time; a pipe of small diameter would draw off a small quantity of steam in a given time; a conductor of high resistance would draw off a small quantity of electric current in a given time.

This question of resistance seems to perplex a good many people. It appears in two ways in signal practice.

(1) Where it is necessary to send current some distance through a line wire, it must be started with pressure enough to deliver the necessary amount of current to do the work needed at the far end.

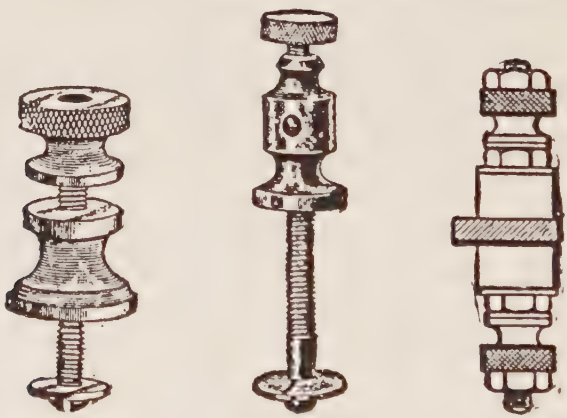


Fig. 65.

(2) Where current is being drawn from a storage or caustic soda cell the conductor must offer enough resistance to keep the drain on the cell down to the lowest point at which enough current to do the work will be delivered in order not to use up the cell unnecessarily fast.

Wires are attached to parts of the machine to the battery, or to each other by binding posts,

which are screw and nut or wide-headed screw arrangements designed for this purpose.

Fig. 65 shows three typical styles of binding posts. The first may be used to attach two wires together, or to attach a single wire to the pole of a battery, for instance. With this type the ends of the wires are bent around into a hook or ring and are passed over the threaded part of the post, after which the nut and jamb nut are screwed down, so as to squeeze the wires together tight enough to insure a good electrical connection.

The second may be used for the same purpose. In it the ends of the wire or wires are passed through a hole in the post and are held in place by tightening down the screw, a thread for which is cut in the post.

The third is a type used where a connection between two wires is made through a terminal board. The wires are fastened to either side, and as the body of the binding post is of brass or some other low resistance metal, the current flows from one wire to the other.

Mechanical interlocking has been on trial for more than fifty years and may be said to have reached its full development. As time goes on minor improvements may suggest themselves, but there is little likelihood of any radical or sweeping changes being made in the method of constructing either the machines, switch movements or signals. The fundamental principle, too, that the power used is always the same—a man's strength—has tended toward the adoption of a very uniform practice with regard to the construction of the apparatus.

With power interlocking, the opposite condition may almost be said to be the case. Some types to be sure have been more or less well known for over twenty years, but hardly a month passes without

the introduction of entirely new devices or improvements in the old.

Anything, therefore, written about the power interlocking of today may become out of date in a very few years.

There are, nevertheless, some general features common to all types, which appear to have settled themselves into standard practice and are likely to continue to appear in any future developments.

The use of compressed air as a source of latent power came to the knowledge of railroad men with the introduction of the air brake, and as early as 1883 the Union Switch and Signal Company had placed its electro pneumatic interlocking on the market. This was followed by the so-called low pressure pneumatic furnished by the Pneumatic Signal Co. Then came the Taylor Signal Company with the first all electric interlocking to come into general use. This in turn was soon followed by the Union Switch and Signal Company's all electric, The Federal Railway Signal Company's all electric, The American Railway Signal Company's all electric, and others which have not yet had the good fortune or the age to get beyond the stage of the prospectus.

I shall now give a brief description of the operating and locking devices and signals used with each of the machines mentioned, and shall add a few words about the machines themselves used by the Federal and American railway signal companies, about which nothing was said in the chapter on locking.

CHAPTER XI.

ELECTRO-PNEUMATIC INTERLOCKING.

The operating power used with the electro pneumatic interlocking is compressed air. This is pumped by an air compressor operated by a steam or gasoline engine or an electric motor, into a large storage tank or reservoir from which it is fed into mains, usually two-inch galvanized pipe, and led in the most convenient way which the nature of the ground will permit to the vicinity of the switches, derails and signals, which the plant is designed to operate, from which it is carried in pipes tapped into the main, to the actual devices by which these switches, derails or signals are moved. The main pipe, and frequently its branches, at least for part of their length, is usually buried in the ground, and for preservative reasons is often encased in a wooden cover which has previously been treated with a wood preserving compound. The air is kept at a pressure of from 65 to 85 pounds per square inch, and as such pressures tend to condense any moisture which is in the air at the time it is sucked into the cylinder of the air compressor, means of draining the pipes are supplied at frequent intervals. Towers for all power interlocking machines are much the same as those for mechanical machines. It is not necessary with an electro pneumatic plant that the air compressor should be at the tower. Very frequently it is placed in a build-

ing some distance away, such as a machine shop or round house, where an engine is required for other purposes, which can also operate the air compressor, or where compressed air is being stored for shop purposes, which by using a larger compressor can also be used for the interlocking plant. There is nothing which corresponds to the leadout of a mechanical plant, with an electro pneumatic plant.

Besides the air compressor an electric battery is necessary. This is usually placed in the basement of the tower. It is sometimes a storage battery and sometimes a collection of primary cells. A wire is run from the positive pole of this battery and is connected to a binding post in one end of the machine, back of the locking bed. The machines for this type of interlocking are so arranged that the locking bed and other parts are contained in a case supported on cast iron legs at about the height of an ordinary man's waist.

The machines are made in two ways, known as the "vertical roller" and "horizontal roller" type. With the vertical roller machine the locking shaft is geared to another shaft placed vertically in the back of the machine, the second shaft being encased in a hard rubber roller. When the locking shaft is caused to make a partial revolution by the leverman's moving his lever, which, as before explained, is really a crank, the gearing causes the roller to revolve also. With the horizontal roller machine the hard rubber roller is slipped over the locking shaft itself between the locking bed and the indication magnets. As a matter of fact the locking shaft is made in three pieces, to the first of which the driver to operate the locking bar is attached, the second is encased in the hard rubber roller, and the third holds the indication segments.

These three pieces are jointed together so as to form one shaft.

A hard rubber rectangular plate, with two sets of shallow parallel grooves, one set running longitudinally and the second at right angles to the first cut or moulded in its side, is set up vertically just in front of the rollers in a vertical roller machine, or is laid down horizontally just under the rollers in a horizontal roller machine. In either case the longitudinal shallow grooves are laid at right angles to the axis of the rollers. In these grooves are laid thin strips of brass or bronze. Thin strips of the same metal bent into arcs of a circle are attached to the circumference of the hard rubber roller in planes either vertical or horizontal,

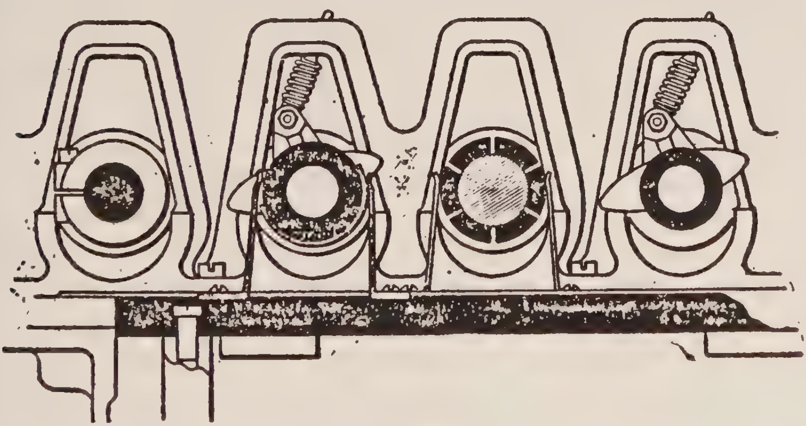


Fig. 66.

as the case may be, coincident with the center line of the brass strips in the rubber plate. Wherever one of the strips in the hard rubber plate passes under or alongside of one of the rollers to which one of these arc shaped strips is attached, the former strip is cut apart and the two ends thus formed are bent away from the rubber plate so as to stand out therefrom on either side of the roller.

Fig. 66 shows a sectional view of a portion of a hard rubber plate, showing the bronze strip attached to its face cut apart, and with the ends bent out and sections of a hard rubber roller with an arc shaped brass strip attached to it.

It should be noticed that in the position shown one end of the strip or band attached to the roller touches the end of one of the bent out brass strips, but does not touch the other. If, however, the roller is revolved the strip attached to it will move with it and will soon come in contact with the bent out end which it did not before touch. It will still, however, remain in contact with the other bent out end. Now if one end of the brass strip attached to the hard rubber plate is attached to one end of a wire, the other end of which is attached to a binding post to which a second wire leading from the positive pole of the battery is also attached, we have made a path for an electric current from the battery up to the bent out end of the strip near the roller, but here the path is broken until the roller is revolved. After it is revolved we know that the current has a path across the roller to the other part of the strip attached to the hard rubber plate. Whether there is a path for it further than that, we have not yet seen. Suppose, however, we attach a wire to the outside end of this second part of the strip, attached to the hard rubber plate, and carry this wire out to a switch a thousand feet away, where we attach its end to the end of a wire which is wrapped around a core to form an electro magnet. Then let us take some more wire, fasten it to the other end of that wire which forms the magnet coil, and lead it back to the machine where we attach it to the negative pole of the battery by means of another binding post.

It can now be seen that we have a continuous

path for the current from the positive pole to the binding post, from the binding post to the bent up bronze strip, where we have a gap made by the hard rubber roller. If the roller is revolved in the direction of the arrow, however, we have a path across it along the other bent up strip, thence along the wire to the magnet, through the magnet coil back on the other wire to the negative pole, through the negative plate and electrolyte, until we come back to where we started at the positive pole. The circuit is, therefore, complete, and the electro magnet out at the switch is energised and holds up its armature. Now what do we want that armature to do?

At the switch we have a cylinder with a movable piston and piston rod, the latter attached to the slide bar of a switch and lock movement similar to that already described for mechanical interlocking. In the end of the cylinder is a valve and the armature of the electro magnet is attached to that valve. One of the pipes leading from the main which connects directly with the air reservoir is connected with one side of the valve, the other side of which opens into one end of the cylinder. When the magnet is energised and its armature up, the valve is open, and compressed air from the pipe rushes in to the cylinder, pushing the piston ahead of it, moving the slide bar of the switch and lock movement, and throwing the switch just exactly as if the slide bar was being pulled or shoved by a pipe line attached to a lever on which a man was pulling or pushing.

Now we have the switch reversed, but we want to get it normal again, how are we going to do it? By cutting another flat strip on the hard rubber plate, bending its ends up just like the first one, attaching another arc shaped strip to the roller, but

so that when the lever is normal it will connect both the bent out ends and when it is reversed the path for the current through them will be broken, leading another wire from the brass strip out to the switch, connecting it to another electro magnet in another valve and back to the negative pole of the battery, just as we did before. This second valve is arranged to let the air in at the other end of the cylinder.

Now we have an arrangement by which, when the lever is normal, air is being admitted to one end of the cylinder, and when it is reversed to the other end, and I will say in advance of a further explanation that the valves are so arranged that when air is admitted at one end of the cylinder it is allowed to escape from the other end, so we see how the switch may be moved from one of its positions to the other by first reversing the lever and then setting it normal again.

There are reasons why so simple an arrangement as that described would not work very satisfactorily or reliably in actual practice, and the valve, or rather system of valves, actually used is a much more complicated arrangement than that described. Instead of two electro magnets there are three, known as the normal magnet, the reverse magnet and the lock magnet. There is a separate wire leading from each of the magnets to one of the brass strips on the hard rubber plate. These strips are so arranged through their bent up ends and the arc shaped strips on the roller that current is sent through the wire leading to the lock magnet as soon as the lever is moved even a trifle, either from its normal or its reversed position. The action of the lock magnet when energised affects the valves so that the other movements will follow.

Fig. 67 shows a section of a switch operating cylinder, the three magnets and valves, in which M^2 is the reverse magnet, M^1 is the lock magnet, and M^3 is the normal magnet. When M^1 is energised it

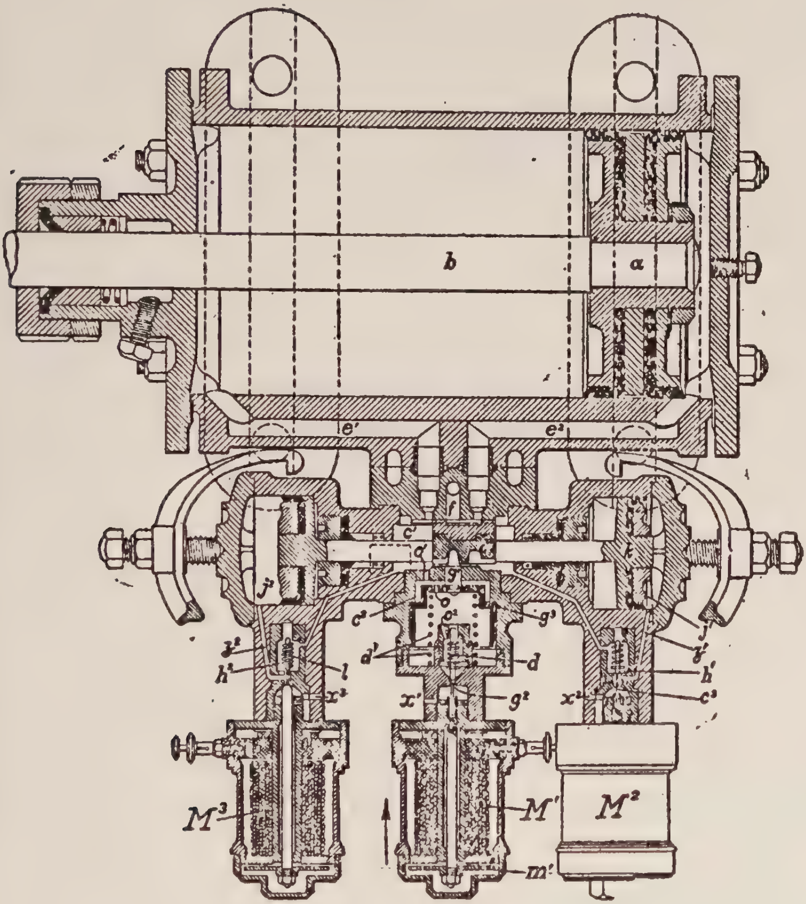


Fig. 67.

attracts its armature m^1, moving the small shaft to which the armature is attached in the direction of the arrow, and compressing the coil spring, d. Between the coil spring and the magnet coil it will be noticed that the shaft which is attached to m^1 is enlarged so as to act as a pin valve. When the

lock magnet M^1 is de-energised, this valve closes the connection between the small air chamber g^2 and the outer air by way of the exhaust port x^1, but when it is energised this valve is opened and the air in c^2 which, as will be seen presently, is compressed air, is free to escape through g^2.

The heavy black line shown as g^3 represents a small piston fitting tightly in the air chamber c^2 and held down by a coil spring d^1 shown in section by the black dots. When the compressed air which was in c^2 escapes, its pressure which has been acting on the piston g^3, in the same direction as the spring, is removed, but the pressure of the compressed air on the other side of g^3 acting against the coil spring still remains. This pressure is enough to overcome the resistance of the spring and to shove g^3 back toward the lock magnet. At the center of the side of g^3, nearest the switch cylinder is a pin shown as g^1. When g^3 is borne down by the coil spring the pin engages a slide valve d^2, which is placed between the ends of two piston rods (omitted from the drawing for clearness of illustration) which are connected to two small pistons k. When magnet M^1 is energised and the air in c^2 is allowed to escape so that the pressure of the air under g^3 compresses the coil spring, the pin g^1 is raised out of engagement with d^2, leaving d^2 free to move. All this, of course, happens in a very brief interval of time, but by the time it has happened the leverman has reversed his lever far enough to send a current through reverse magnet M^2 by making another connection on the roller in the machine. The action of this magnet is much the same as is that just described of M^1, that is, its armature is attracted, pushing the armature shaft toward the large cylinder and opening a valve at h^1. It does something more, however, and also

closes a valve at c^3, thereby preventing any air from escaping through exhaust x^2.

The opening of the valve h^1 makes a connection between the air chamber which connects directly to the main air pipe, and the air space back of piston k. This allows air to get behind k and shoves it toward the left, carrying with it slide valve d^2.

At the same time that magnet M^2 is energised, magnet M^3, which has been energised until then, is de-energised. Spring 1 forces the armature shaft outward and a connection is made for the compressed air, which is behind piston j^2, to escape through exhaust port x^3, thereby removing any resistance to the movement of piston k, behind which compressed air is rushing from the main air pipe.

When d^2 has reached a point where its hollow lower side bridges over the main exhaust port f and the connection to the main cylinder e^1 the compressed air in the cylinder is free to escape through the main exhaust port f. At the same time compressed air from the main pipe passes behind d^2 and into the connection to the main cylinder, thereby getting behind the main piston and shoving it to the opposite end of the main cylinder, which reverses the switch. The leverman has now reversed his lever far enough to break the circuit through lock magnet M^1, which becomes de-energised. Its armature is pushed back by the small coil spring, thereby closing the connection to the exhaust port x^1. There is a very small hole through the end of piston g^3 near pin g^1, through which the compressed air from the main pipe soon fills up air chamber c^2. The pressure of this air joined to the pressure of the coil spring forces g^3 toward the main cylinder and locks slide valve d^2 in its reversed position. The fact that this hole is as small as it is—much smaller

than exhaust port x^1, or the connection to the main air pipe, prevents enough air from escaping through it to fill up c^2 as fast as the air from c^2 escapes through x^1 when M^1 is first energised.

The switches operated by the cylinders of electro-pneumatic plants are fitted with front and lock rods, detector bars, braces and tie plates, in all essential particulars exactly as those operated by a mechanical plant are fitted up, and the switch is locked by the switch and lock movement in exactly the same way.

CHAPTER XII.

ELECTRO-PNEUMATIC INTERLOCKING—CONTINUED.

In the earlier part of the foregoing description, where I explained the action of the contact strips attached to the hard rubber plate in the machine frame, and the running of the wires from the machine to the switch movement, I omitted for the sake of clearness a few points that I shall now take up.

In the first place I spoke of the bronze strips being bent up to make contact with the arc shaped strips or bands on the rollers. Taken literally this is not the exact case. The strips laid flat in the grooves of the plate are cut, but instead of bending the ends up to the roller, other strips bent to the required shape are screwed down to the hard rubber plate on top of the flat strips tight enough to insure a good electrical connection, and as will appear further on the flat strips, all except two, are laid in the cross grooves instead of the longitudinal ones.

As regards the wiring. One wire is led out to each of the three magnets, but there is only one wire returning to the negative pole. It is a fact which seems a little strange at first, but is plain enough on reflection, that as many wires may be led out of a battery from one pole as we please, and that after the current carried by each of them has done its work, they may all be connected to

one wire called the "common return wire," or "common" wire, and the circuit for each of them completed through this one wire.

The wires leading out to the magnets are called the control wires. The common wire should be a heavier one than the control wires so as to offer the minimum of resistance.

Attached to one end of the switch and lock movement is a small oblong cast iron box, called the indication box, raised a little above the plane of the upper slide bar. This box is divided longitudinally down the middle into two equal compartments by a strip of vulcanized fibre, which is a material having a very high resistance, and is, therefore, a good insulator.

In each of these compartments are two stiff brass springs. The ends of these springs near the middle of the box, taken lengthwise, are fastened to mica or fibre plates, which lie horizontally across the box, by binding posts. These ends are not allowed to touch each other and hence do not form part of an electric circuit. The other ends of these springs are bent downward. Two wires, with their other ends connected to the positive pole of the battery in the tower, are attached to one end of the wires which make the magnet coils of the indication magnets in the back part of the machine. Other wires are connected to the other ends of these coil wires and from there are led out to the binding posts which connect with the brass springs in opposite ends of the indication box, but in the same compartment.

Other wires are connected to the binding posts in the opposite compartment of the indication box, the other ends of which join to the common return wire.

This explanation is given to show the reader as clearly as possible how the indication circuit is

made through the indication box. In actual practice as is explained a little further on the current goes out to the indication box on the lock control wire, and returns on two separate wires through the magnets to the common wire.

A lug is attached to the upper slide bar in such a way that when the switch and lock movement is in its normal position the top of this lug, which is of a low resistance material and is carefully insulated from the slide bar, bears against the ends of the two springs in one end of the indication box, thus completing a circuit from the positive pole of the battery through one of the indication magnet coils, to one spring in the indication box, across to the other spring by way of the lug on the top of the slide bar of the switch and lock movement, from the last named spring to the common wire and along it to the negative pole of the battery.

When the switch and lock movement is moved toward the reverse position, this lug soon gets beyond the bent down ends of the springs and ceases to touch them. The circuit is then broken. Just before the switch and lock movement completes its stroke, however, the lug touches the ends of the two springs in the other end of the indication box, making an electrical connection between them, thus closing the circuit through the other indication magnet in the machine. Therefore, whenever the switch and lock movement is at the full end of its travel, a circuit is completed through one indication magnet or the other. It is not advisable, however, to leave this circuit closed all the time, as it serves no useful purpose to do so, and simply draws current from the battery unnecessarily. So instead of running wires direct from the positive pole of the battery to the indication magnets, a connection is made near the switch between the positive side

of the indication box and the lock control wire. Two wires are then run from the negative side of the indication box, one to each indication magnet, and from there are carried by contact springs across the hard rubber roller, which is moved when the lever moves in practically the same manner in which the lock circuits and normal and reverse switch valve circuits are carried across, but are then connected by the common wire to the negative pole of the battery. This will be explained presently after we have said a few words on the divisibility of electric currents.

There is another difference, also, which is this: The hard rubber roller to which the arc shaped bands which complete the circuit for the indication wires are attached, is not a part of the same hard rubber roller to which the circuit closing bands which connect the lock and valve wires are attached. It is a separate roller, encasing the same shaft, but so arranged that it does not commence to move until the lever has made five-sixths of its stroke. It then commences to move and soon makes the contact by which the circuit through the indication magnet is closed—either the reverse or normal—according to whether the lever is being reversed or set normal.

When the indication magnet becomes energised the lever is free to complete its stroke as already described in an earlier chapter, but in so doing it breaks the circuit through the indication magnet and leaves it de-energised.

The cylinders used to operate high signals are different from those used to operate switches. They are attached vertically to the signal poles and compressed air is admitted to one end only, so as to shove down on the piston which is connected to the up and down rod by a straight arm compensa-

tor which reverses the motion so that an upward thrust is transmitted to the up and down rod. The force of gravity is depended on to restore the signal to the normal position.

There is but one indication given by a signal, and this is from its normal position. When the blade goes to clear, it does not indicate. The reason for this is that if a signal should stick in the normal position after the leverman had reversed the lever no great harm could be done by his then being able to reverse other levers which the first lever would have unlocked. The mechanism of these signals is very reliable also, and the chances of their sticking at normal are remote.

It is the general practice to place the signal cylinders at the base of the pole and to run the up and down rods inside of the pole.

Recently some electro pneumatic signals have been manufactured which have the cylinders on the top of the pole. This is a mode of construction which, as will be seen later, appears in several types of electric signals.

The cylinders of electro pneumatic dwarf signals are in the base of the pole, and are so arranged that they shove up only on the up and down rod, against the action of a strong coil spring. When the air is released this spring acts as a counter weight and restores the signal to normal. In the case of the dwarf signal the piston remains stationary, while the cylinder itself to which the up and down rod is attached moves upward by the reaction of the compressed air against the fixed piston.

Instead of the indication box as used with switch movements, the indication circuit is closed, on the dwarf signals by a brass plate attached to the side of the cylinder, which, when the signal is normal and the cylinder down, presses against a stiff

vertical spring in the bottom of the dwarf signal case. The wire forming the indication circuit is attached to this spring by a binding post, where it is cut off and the severed end attached by another binding post to the brass plate, so that when the cylinder is up and the signal clear the indication circuit is broken, but when the cylinder is down and the signal normal, the indication circuit is closed.

With high signals a circuit controller made of two springs which do not touch each other between which a low resistance slide is forced when the signal is normal by the movement of the piston, is bolted to the side of the cylinder. The cylinder air valve with its electro magnet and circuit controller is protected by a neat cast iron casing, which is fastened to the signal pole or ladder by a chain so that it cannot be carried away and the mechanism left exposed.

With both high and dwarf signals the circuit controllers should always be insulated from the poles.

It should be noted that there are no balance levers, "L" cranks or counter weights with these signals. The arm plate castings are made very heavy on the side opposite the blade, and the up and down rods are of solid iron instead of pipe, which gives them considerable weight also, so that counter weights as they appear with mechanical signals are dispensed with.

As stated in a previous chapter on locking, a switch and signal lever are differently arranged in an electro pneumatic machine. We will now consider the points of difference.

In the first place signal levers are always arranged in the machine so that they extend below the horizontal line through the centers of the locking shafts, while switch levers are arranged to ex-

tend above that line. Incidentally it may be said that switch levers are always given odd numbers, while signal levers are always given even numbers.

In their normal position signal levers are vertical.

In their normal position switch levers are inclined to the left of a person facing the front of the machine, at an angle of 30 degrees from the vertical.

When reversed signal levers may be thrown either to the right or the left of the vertical, 30 degrees to either side.

When reversed switch levers can be moved only to the right of the vertical, also 30 degrees, making their full stroke 60 degrees.

From the above it will be seen that signal levers have two reverse and one normal positions, and can, therefore, be used to clear two signals. The principal of having switches select their signals is also used wherever possible. This affects a great saving in the number of levers necessary to operate the signals at a given plant.

The method of closing the indication circuit, or as it is called when a signal lever is referred to, the lock circuit, is also different. Both switch and signal levers are held in their normal or reversed position by small latches which are pressed down by springs and are intended to prevent levers being unintentionally moved by a person brushing along the front of the machine.

When the leverman takes hold of the small hard rubber knob which serves as a hand hold, he has to press it away from the fulcrum of the lever in order to unlatch the lever, so that he can move it. As the signal lever does not have to get an indication, or be unlocked, in a movement from normal to reverse, as a switch lever does, it has only one

magnet to energise and consequently one circuit to close.

The latch in the handle is made to work a circuit controller near the front of the machine for this purpose. This saves having the extra hard rubber roller for a signal lever that is required for a switch lever with its contact strips and other attachments.

As with other mechanical apparatus, it is the object of the designers of interlocking machinery not to use more material in its construction than is absolutely necessary to accomplish the work for which it is intended.

It is another fact about electric currents, that in case a conductor is divided, the current will also divide itself, and follow each different part of the conductor, provided they all offer an unbroken path for its return to its source. The question of resistance has to be taken into consideration in some cases where this principle is applied, but just now we will omit reference to that part of the subject.

This quality of divisibility of an electric current is made use of in constructing electro pneumatic interlocking machines, and in a great many other ways, as well, in signal work.

Heretofore I have considered the action of one lever taken singly with regard to its action in operating a switch or signal but where there are many levers together in an interlocking machine, the question of economizing space and material comes to the fore.

From the principle of the divisibility of the current, it is easily seen that it is unnecessary to have more than one wire attached to the positive pole of the battery, and if this wire can be brought up to the hard rubber plate in the machine, which we will hereafter call the contact plate and there ar-

ranged so that each of the bent up brass strips will act as a separate branch of this conductor, we may feed a great number of circuits from it and save a great many separate wires and their connections between the brass contact strips and the battery.

Fig. 68 shows a view of a contact plate with hard rubber roller crossing it. It will be noted that two

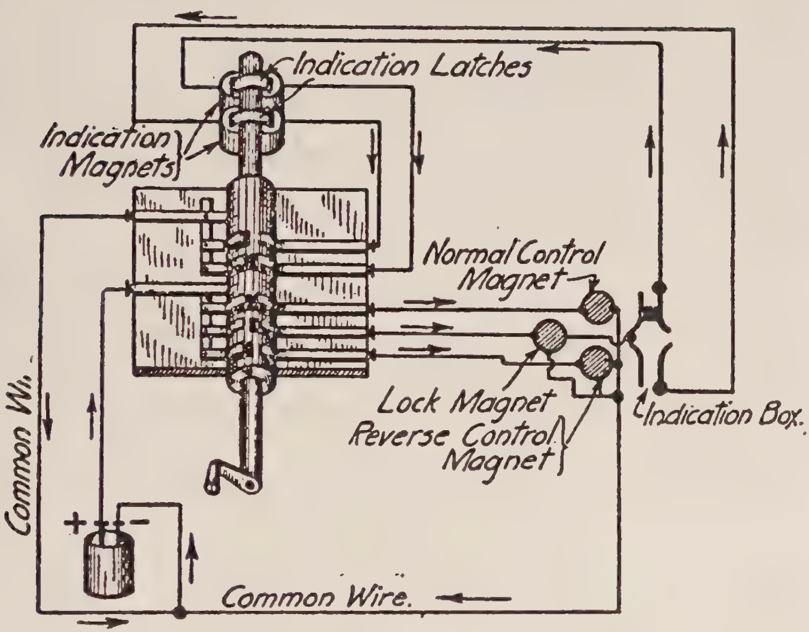


Fig. 68.

of the strips, and only two, extend to the left side of the contact plate. To one of these the feed wire from the battery is attached by a suitable binding post.

The other is attached to the common wire near the negative pole of the battery, and is used as a path for the return current which operates the indication magnets back to the battery.

The lever represented in the figure is a switch lever and has five contact strips raised on each side of it,

and five arc shaped bands attached to it. The ends of three of them are connected to another strip running at right angles to the strip to which the feed wire is connected and parallel to the roller. This transverse strip not only connects each of the three contact strips on one side of the roller together, but also joins them to the long feed strip sometimes called the battery strip. The current, therefore, may come from the battery to the feed strip, along the transverse strip to the first contact strip, and if the circuit is closed through that, part of the current will be drawn off there. If another or all of the other contact strips should be part of closed circuits, each would draw off its share of current from the battery.

The two other contact strips on the same side of the roller are also joined together by another transverse band, which connects them to the second longitudinal strip. These are the contacts for the indication magnets. The second long strip is connected to the common wire.

The contact strips on the other side of the hard rubber roller, it will be noticed, are not connected together, or to the feed strip. These are joined by screws through the contact plate to binding posts on its lower side, from which wires are run to separate binding posts on the terminal board already mentioned, which is attached to the back of the machine, so that external wires leading to the lock magnet, the normal and reverse valve magnets, and the indication box may be joined to them by being attached to the same binding post, on the other side of the terminal board.

As before stated it is neither necessary nor advisable to keep the indication magnets on a switch lever energised longer than just time enough to re-

lease the lever so that it may complete its stroke, so a use of the principle of divisibility of current is made there.

The contact strips and bronze contact bands on a switch lever by which current is sent through the lock magnet are so arranged that the lock magnet is not energised except when the lever is part way over, either toward its full reverse or full normal position, and it is while the lever is in this position that the indication circuits need to be closed. The two springs in the indication box which are connected to the positive pole of the battery are, therefore, joined together in the indication box by a small brass strip held down by their binding posts, and a short wire is run from one or both of these binding posts in the indication box to connect with the lock magnet wire from the machine. The current which comes out from the positive pole of the battery on the lock magnet wire divides near the switch, therefore, and whenever the switch is in either full position so as to close one or the other of the indication circuits part of this current crosses through the indication box.

In the side of the indication box opposite that to which the short wire connecting to the lock magnet wire connects, the springs are not joined, and by their binding posts are connected independently to the normal and reverse indication magnet by wires running back to the machine. The other sides of the indication magnet coils are connected to the common return wire and by that the current finds its way back to the negative pole of the battery. Thus it may be seen that the current energises the indication magnets as it returns from the switch, instead of as it goes out to the switch; any break in the lock magnet circuit also breaks the indication circuit so that when the lever is in its full nor-

mal or reversed position which can only be after the switch has gone to its full normal or reversed position and has closed the circuit through the indication box, the indication circuit is broken at the hard rubber roller because the lock circuit is also broken there. This saves unnecessary battery consumption.

It is sometimes convenient to operate both ends of a crossover with one lever, both in mechanical and electro pneumatic work. Where this is done with the electro pneumatic, separate cylinders and switch and lock movements are put in at each switch, but the lock wire, the normal and the reverse valve wires are run through the corresponding magnets at each switch before being connected with the common. In this way, every time that one of them is energised the other must be also, being on the same circuit, so that the switches perform exactly alike. In the same way both indication circuits are run through both indication boxes, and unless, therefore, both switches are over and locked, the indication magnet will not be energised and the lever will be prevented from making its full stroke. Movable point frogs are thrown by tandem switch and lock movements.

Besides the type of switch and lock movement already described, one using a motion plate instead of an escapement crank, is sometimes used, and in some cases the lock, normal and reverse control magnets and their valves, are fitted to the end of the switch cylinder instead of on its side. These are mere details of construction and have no bearing on the principle involved in this apparatus.

It is a general custom to turn out electro pneumatic machines with what is known as a *track model* fastened to the back of the machine. This track model consists of an upright solid wooden

frame on which a plan of the tracks, with the switches operated by the machine, is shown by rectangular brass rods; miniature signals are also shown. The switches and signals are made movable and are mechanically attached to the levers which operate them, by small cranks and rods, so that the leverman has a moving model of the switches and signals controlled by the machine before him as he operates the machine.

It may be that years ago when expert levermen were scarce, this track model served some useful purpose, but other makes of machines are now successfully operated without it. Its cost is considerable and as trained levermen may always be had, it might as well be dispensed with.

As will be noted later, what is known as a manipulation chart, which also comprises a track and signal plan, should be hung up in every tower.

As before stated, the air pipes of an electro pneumatic plant are provided with drainage. The air, too, after leaving the compressor is run through cooling coils and such moisture as is thereby condensed is held in the main reservoir where it can be drained off whenever necessary by suitable stop cocks. At each switch or signal movement an auxiliary reservoir is provided, into which the air from the main pipe is emptied, and from which it is drawn off to the switch and signal cylinders. These auxiliary reservoirs catch any moisture which is not deposited in the main reservoir, and it is from them that the drainage is made by stop or blow off cocks.

Gate valves are also cut into the main air pipe at frequent intervals so that in case a leak should occur in this pipe some distance away from the tower, air may be shut off from the broken part, and all switches and signals between the point where

a gate valve is closed and the machine kept working while repairs are being made. Each of the small pipes leading to a switch or signal cylinder, too, is provided with a stop cock, so that that particular switch or signal may be cut out, in case of a leak, without necessitating the shutting down of the entire plant.

The connections from the auxiliary reservoirs to the operating switch cylinders are usually flexible, steel covered hose being generally used. Trains passing over switches jar the connections a good deal, and by having them flexible this jar is not transmitted to the connection with the auxiliary reservoir.

With the signal cylinders this does not matter so much, as the signals are not moved by the deflection of the rails in the track.

The wire used is copper, covered with a coating of a compound of india rubber from 3/64 in. to 5/64 in. thick over which one or two strands of braid are wound. Cables are often used for switch and signal movements. It is as well to have two or three extra wires in the cables, so that in case one breaks inside, the circuit of which it forms a part may be transferred to a spare wire.

The control wires are usually No. 12 or No. 14 Brown and Sharpe gauge and the common No. 8 or 9.

The wires or cable are carried in a conduit usually called trunking. Where the circumstances do not require that this should be very large it is often grooved out of two, three or four inch plank, with a flat board called the cap to close in the fourth side or top. Large trunking is generally made of four planks, which should be dressed to exact size, if a good looking job is desired, nailed together to form

a box. The object of trunking is to protect the delicate wires from mechanical injury.

The best practice is to keep the trunking above ground. Where this is done, it should be nailed to a row of stakes set 8 feet apart. Three inch by 4 inch oak stakes, 4 feet long, the same as those used for wire lines at mechanical interlocking plants are as good as anything, and look neat. Some signal engineers prefer to use cedar fence posts, sawed in two, and others use stakes made of old boiler flues or old pipe.

Wooden trunking is one of the most unsatisfactory classes of material a signal engineer has to use. Frequent attempts have been made to introduce an underground conduit of some sort, but the ability, which overground trunking affords, to get at the wires at any time without much labor, is an advantage.

Care should be taken in nailing down the capping not to let the nails dodge and break or cut through the insulation of wires or cable inside the trunking.

Where wires have to be led away from the main trunking line, it will be found very convenient to use a junction box. This is a box let into the trunking, inside of which is a terminal board usually of slate or porcelain, or some high resistance material, into which several binding posts are screwed. The wires in the main trunking have their ends attached to the binding posts, and the wires which lead from them are attached to the same binding posts.

The reader may have noticed that in every case where connections for circuits are made and broken intermittently, it is by a spring rubbing against a plate. The contacts across the hard rubber rollers are made by the arc shaped bands sliding against the ends of the contact springs; the contacts in the

indication box are made by the lug fastened to the top of the slide bar of the switch and lock movement sliding against the springs in the box. The reason for this is that these contact pieces are most conveniently made of brass or bronze. Around railroads there are always certain gases in the air, thrown off by the combustion of coal, which gases have a corrosive effect on most metals, and brass in particular. The product of this corrosion is apt to form on the surface of the contacts. Some of these products are of very high resistance and form a serious hindrance to the ready passage of electrical currents. By having sliding contacts the action of one brass or bronze piece against the other has a tendency to rub off these products and to keep the contacts bright.

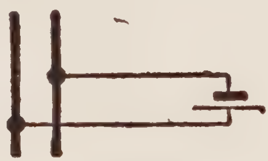


Fig. 69.

The battery used with electro-pneumatic machines is nowadays invariably a storage battery. In early installations gravity cells were used. The electric pressure required is not very great, from 12 to 15 volts being ample. Six or seven storage cells connected in series is sufficient for a very large plant. These cells have a pressure of approximately 2 volts each and by connecting them in series the sum of the voltage in all the cells is made the pressure of the battery. When the cells of a battery are connected in series the positive pole of one cell is connected to the negative pole of the next cell to it, the positive pole of that again is connected to the negative pole of the one ahead, and so on throughout the battery. The last positive pole is

connected to the outgoing conductor, and the incoming conductor is connected to the first negative pole. In this way the current from each cell flows through every cell in the battery, either as it goes out or as it comes in.

The conventional method of showing a battery in a drawing is illustrated in Fig. 69. The long line is the positive side of each cell, and the short heavy line the negative side. The algebraic sign plus is also used to denote the positive side of the battery, and the algebraic sign minus to denote the negative side.

CHAPTER XIII.

LOW PRESSURE PNEUMATIC INTERLOCKING.

Low pressure pneumatic interlocking attracted some attention in this country several years ago, but has been almost lost sight of since the introduction of all electric interlocking.

It appears, however, to be redivivus in Great Britain, the British Pneumatic Railway Signal Company having taken it up in that country, and a brief description of this system here, may, therefore, not be amiss.

The fundamental principles in which it differs from the electro-pneumatic are that no electricity is required in its operation, and that its work is done with compressed air at a much lower pressure than that used by the latter.

The first feature, the absence of electricity, was, at one time, a point much in its favor, the maintenance of electrical devices in connection with signal work requiring the services of specially trained men who a few years ago were not easily obtainable. At the present time, however, as so much electrical apparatus is used in other ways for signaling purposes, and as the supply of expert maintainers is constantly increasing, so that competent men may always be had, the elimination of the electrical feature from power interlocking would in most

cases fail to reduce the cost of maintenance to any appreciable extent.

The use of low pressure air was intended to prevent the condensation of the moisture taken into the compressor with the free air used as well as to economize in the use of power to compress it. As an offset to this the precautions taken to prevent the failure of the electro pneumatic apparatus from the freezing of water in the pipes during cold weather appear to be effective and the fact that cylinders of so much smaller diameter may be used without diminishing the power applied to the movements, is distinctly in its favor.

The machine used with the low pressure pneumatic is, as far as the levers and locking go, very similar to that used with the General Railway Signal Company's (the Taylor) all electric machine, mention of which was made in the chapter on locking. The locking is of the vertical type. The tappets are lowered when the lever is reversed, wherein the locking differs from the all electric machine just alluded to, in which the tappets are raised and the levers are flat bars brought down to a square shank on the end of which is a vertical handle by which they are pulled out from the body of the machine in a vertical and horizontal plane when being reversed, and shoved in when being returned to normal.

The compressed air for operating the switches, signals, etc., is, as with the electro pneumatic, stored in a reservoir at some convenient place. Four pipes are led from each switch lever to the switch it operates and three from each signal lever to the signal, in addition to which another pipe of larger diameter connects the switch or signal cylinder through the medium of so-called relay valves, with the main reservoir.

The levers have two slots cut in the flat part which slides in the machine frame. The slot in front operates the tappet exactly as with the all electric machine, except that as before stated the motion is reversed. The second slot serves to make the indication effective. In a switch lever which we will first describe its shape forms three sides of a trapezoid, one side being parallel to the axis of the lever and the other two sides forming equal obtuse interior angles with the first side.

A cylinder with valves arranged to admit air from either end is placed at the switch, with its piston attached to a motion plate switch and lock movement very similar to that already referred to as occasionally used with the electro pneumatic. This switch and lock movement besides throwing and locking the switch, also moves a slide valve by which compressed air is admitted to one of the pipes leading from the lever, and is excluded from another one which is connected to this valve. The compressed air being alternately admitted to and cut off from these pipes, as the switch is in full reverse or full normal position, and locked there.

At the lever end each of these pipes is connected with a separate relay valve connecting with a separate cylinder placed beneath the lever. The piston rods of these cylinders extend upward and terminate in rollers which are arranged to travel in the trapezoidal slot in the back of the lever. When the lever is normal the roller at the end of the piston rod of the forward cylinder is at the far forward end of the slot which raises it, the piston rod and its piston to its full upward stroke. The roller of the other piston rod rests on the lower straight part of the slot and is then at the lowest point of its stroke. These are the indication cylinders.

Back of the lever and attached thereto is a slide valve controlling a connection between the main reservoir and the two other pipes leading from the lever to the switch cylinder. One of these pipes connects with the relay valve at one end of the cylinder, and the other with the relay valve at the other end of the cylinder. These relay valves have a large 8-inch diameter flexible diaphragm, so that a very little pressure is sufficient to move their pistons, which have a stroke of about a quarter of an inch only. The main air pipe also connects with each of the relay valves.

When the leverman reverses his lever it is stopped about midway of the stroke by the roller in the upper end of the piston rod of the back indication cylinder coming in contact with the vertical side of the end of the horizontal part of the trapezoidal slot. It has traveled far enough, however, to have moved the slide valve to which the back of the lever is attached into such a position that air is allowed to flow from the main reservoir along the pipe leading to the relay valve at the end of the switch cylinder at which its piston rests when the switch is normal. This air is admitted through a much smaller opening than the diameter of the pipe through which it flows, and is, therefore, used expansively so that its pressure is reduced from 15 pounds per square inch above atmospheric pressure, which is the pressure in the main reservoir, to about 7 pounds per square inch. At the relay valve this air is admitted under the flexible diaphragm, thereby raising its piston and opening a connection between the main pipe leading from the reservoir and the switch cylinder back of the latter's piston. The opposite end of the main cylinder being opened to allow air to escape from it. The air in the main

pipe which is at full pressure—15 pounds per square inch—rushes into the switch cylinder and pushes the piston toward its other end. This starts the switch and lock movement, which like all such devices, first unlocks the switch and raises the detector bar, then throws the switch and lastly locks it reversed and drops the detector bar. The indica-

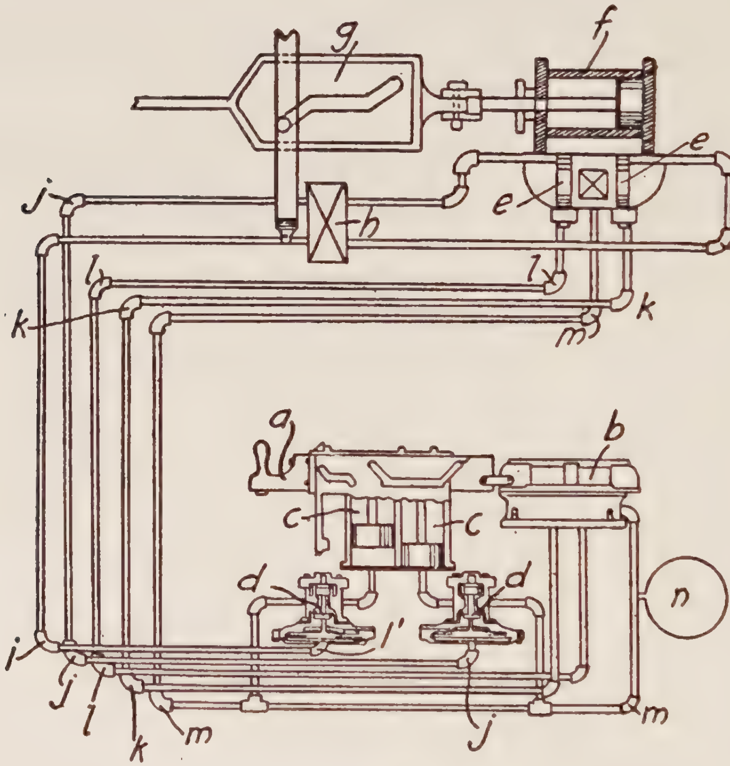


Fig. 70.

tion slide valve is moved by the first and third positions of the stroke of the switch and lock movement.

The first movement of the indication slide valve cuts off the air supply from the indication cylinders

in the machine through the relay valves in the machine frame, already mentioned, which are similar to those at the switch. The last movement which is not completed until the switch is locked reversed, admits air from the main pipe through the medium of one of the indication relay valves in the machine to the rearmost indication cylinder, tending to force its piston upward. The shape of the back end of the trapezoidal slot is such that this upward pressure on the piston, and through it on the piston rod of the rearmost indication cylinder, forces the lever automatically into its full reversed stroke without the aid of the leverman, and unlocks such other levers as are to be unlocked. In returning the lever to normal this process is reversed, except that the forward indication cylinder comes into play instead of the rear one.

Fig. 70 illustrates diagramatically this operation. In the figure a is the lever, b is the operating slide valve, c c are the normal and reverse indication cylinders, d d are their respective relay valves, e e are the relay valves at the switch cylinder, f is the switch cylinder itself, g is the switch and lock movement, h is the indication slide valve, i i i and j j j are the normal and reverse indication pipes respectively, k k k and l l l are the normal and reverse operating relay valve pipes, m m m is the main air pipe and n is the main reservoir.

Signal mechanisms are much the same as switch mechanisms. Like the electro pneumatic, signals only indicate from the normal position. In fact, this rule is general to all forms of power interlocking. As there is only one indication, the rear slot in the signal lever is only half of the trapezoidal form of that in the switch lever. There is but one indication cylinder with its relay valve for each signal lever in the machine.

Fig. 71 shows a signal lever, signal and the operating mechanism. When the leverman reverses the lever he admits air at 7 pounds pressure along pipe l l l to relay valve e. This valve opens the connection between main pipe m m m and the lower end of cylinder f. The air from pipe m m m being at 15 pounds pressure, pushes up the piston, clearing the signal blade. There being no indication from this movement the leverman reverses the lever all the way at one stroke.

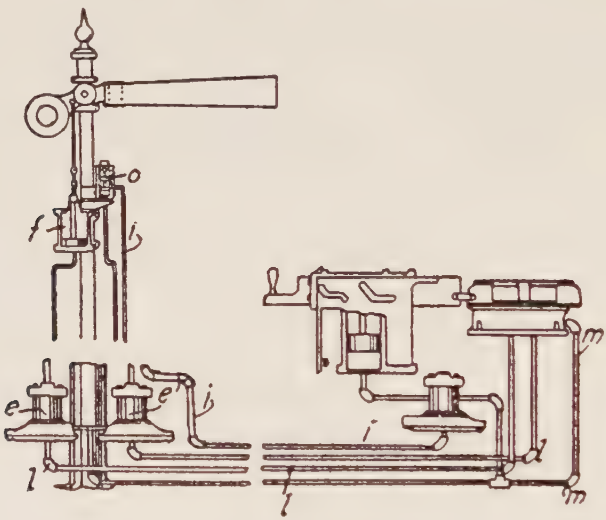


Fig. 71.

When he returns the lever to normal again it is stopped in mid stroke by the roller on the upper end of the piston rod of the indication cylinder. Air is being admitted to relay valve e, however, by which it is in turn admitted to indication cylinder o, and from there to the upper end of the operating cylinder. This forces the piston down and returns the signal to normal. When at full normal a valve in o is moved so as to admit air to pipe i i i, which acts on the indication relay valve and indication cylinder exactly as in the case of a switch.

Dwarf signal movements are identical with high signal movements in principle, though differing slightly in detail of construction.

CHAPTER XIV.

ALL ELECTRIC INTERLOCKING GENERAL RAILWAY SIGNAL COMPANY'S TYPE.

With all electric interlocking the electric current itself, converted into mechanical power by means of electro magnets (it is here to be understood that the shaft of an electric motor is made to revolve through the application of the principles of magnetism), is used to supply the power by which the switches and signals are moved.

Mechanical power, as is pretty generally known, is measured by a unit called a horse power. A horse power is that force required to raise a weight of 33,000 pounds, one foot high in one minute.

Mechanical power supplied by an electric current acting through electro magnets is not, as a general thing, measured by horse power, but by a unit called a watt. It has been calculated that 746 watts are equal to one horse power.

It may be said here that the number of watts produced by any battery or generator is equal to the product of the number of volts pressure in the battery and the number of amperes of current which the battery is giving forth. A battery with an electric pressure of two volts, giving forth fifty amperes of current would be able to perform one hundred watts of work, or a little less than one-seventh of a horsepower. A fifty ampere drain on a battery is so great

that it would require the renewing of a primary or recharging of a storage battery at very frequent intervals, so that it has been found to be much more economical to increase the pressure of the battery and use fewer amperes. Currents delivered under a very high pressure are dangerous to persons who may be accidentally shocked by them, and it has, therefore, become pretty general practice to use 110 volt batteries for all electric interlocking. With the type we are now concerned with—the General Railway Signal Company's, the battery is universally a storage battery which receives its charge from a dynamo driven by a gasoline engine, or by an electric motor, if the plant is so situated that current may be had from an electric lighting plant or electric railway, with which to drive the motor. The battery should always be of a large enough capacity in ampere hours to operate the plant for from seven to ten days, on one charge. That is, it should be only necessary to run the dynamo once every seven to ten days.

Such an arrangement makes the furnishing of power for these plants very economical.

The quite general practice is to place the battery in the lower story of the tower. Where a gasoline engine is used to run the dynamo, some signal engineers put it and the dynamo in a separate building, twenty-five to thirty feet away from the tower, in order to avoid as much as possible the chance for the destruction of both generating plant and battery in case the engine room should catch fire. Some years ago at a large plant in Chicago, which was arranged in this way, the engine room with the engine and dynamo were burnt up the day after a charge had been given the battery. The plant was kept in operation without a moment's delay on this charge until

a new engine and generator were procured and installed.

Other signal engineers prefer to build their towers of fire-proof material and place the dynamo and engine in its basement, as well as the battery.

This latter practice has a very serious objection in the fact that the levermen upstairs are now-a-days very largely dependent on the use of the telephone for conducting their business, and the noise of the engine and dynamo, whenever the battery is being charged, seriously interferes with its use.

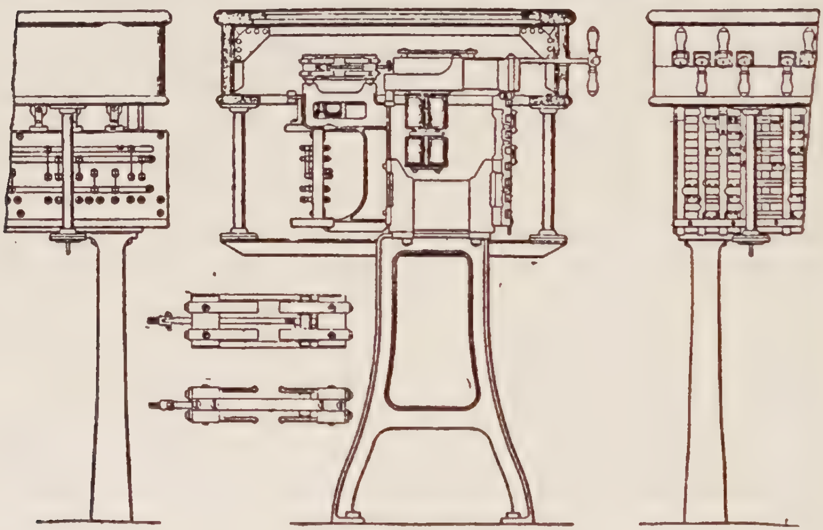


Fig. 72.

The machines used are not unlike those of the low pressure pneumatic. The levers, as in the latter, are slides which move horizontally backward and forward in the machine. The tappets are raised upward to perform the locking, as described in an earlier chapter. The slide valve of the low pressure pneumatic is replaced in the all electric by a double circuit controller so arranged that when the lever is nor-

mal (shoved in) it closes one circuit, and when it is reversed (pulled out) it opens that circuit and closes another nearer to the front of the machine.

The indication cylinders are replaced by indication magnets, and below the indication magnets are what are known as safety magnets, the use of which will be explained a little further on.

Fig. 72 shows three views of one of these machines, and also, drawn much out of proportion for the sake of clearness of illustration, at the lower side

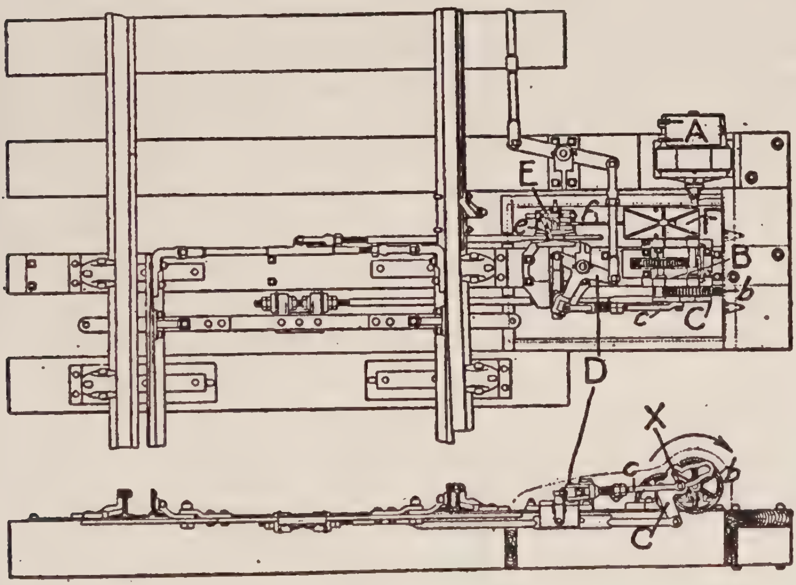


Fig. 73.

of the plate one of the circuit controllers which the levers operate.

But one style of switch operating machine is used with this type of interlocking. It may be applied to switches, derails or movable frogs. This switch machine differs materially from anything yet described, so that we will now give a detailed explanation of it.

Fig. 73 illustrates one of these machines in plan and section, showing its connections with a switch and detector bar.

A is a small electric motor. B is an arrangement of gears operated by the shaft of the motor through the means of which the speed of the last gear in the combination is much slower than that of the motor shaft and power is gained proportionately.

This power is transmitted to a cam crank C, the lower arm of which is connected by a special switch adjustment to the head rod of the switch. The main gear of the combination B, shown as b in the drawing, has a crank pin fastened in its side, which not only serves to operate the cam crank, but is also joined by a connecting rod c to one arm of a three

Fig. 74.

arm crank D, another arm of which is connected by a link to a straight arm compensator through whose medium it throws the detector bar. The third arm of this three arm crank D is connected by a specially shaped link to a double lock plunger, which is shown in Fig. 74. It will be noticed that the throw rod of the switch, one end of which is connected to the cam crank C and the other end of which terminates in the special switch adjustment, is flattened where it passes the center of the three arm crank support. One point of the lock plunger passes through a hole in this flattened part of the throw rod, and the other point passes through a hole in the regular lock rod, just as is the case with any facing point lock, so that the switch points are double locked.

E is a pole changing switch operated by a small lever c, which is engaged by two small lugs on top of the lock rod, so that when the switch is normal the end of this lever which is engaged by these lugs is thrown away from the center of the track, and when the switch is reversed it is thrown toward the center of the track. The motion of this lever is transmitted by the operating rod f to the pole changer F, *after the lock plunger has passed through the lock rod, but not until then.* The use of this pole changer will be explained presently.

The motor B is constructed with a double set of what are known as *field coils.* It is by passing a current through these field coils that the revolving part of the motor, called the *armature,* is made to revolve; being keyed to the shaft it turns that also. One set of these field coils when energized causes the motor to revolve in one direction, and the other set causes it to revolve in the other direction. Part of the function of the pole changer is to switch the path for the current from the battery from one set of the field coils to the other.

In the back of the machine are three brass bars ¼"x½" in section, laid horizontally parallel to each other in the same vertical plane. These are called *bus bars,* and perform the same function that the battery strips on the combination plate of an electro pneumatic machine perform, namely, to make a convenient common means of connecting the external circuits with the positive or negative poles of the battery. The upper one of these bus bars is used exclusively for control wires leading out to switch machines, the middle one for indication wires, and the lower one for control wires leading to signals, and are known respectively as the switch bus bar, the indication bus bar, and the signal bus bar. There are two common wires known as the *main common*

and the *indication common.* The main common runs through the entire plant. The indication common is cut into various sections which are joined to the main common which connects to the negative pole of the battery. The main common wire does not connect with the bus bar, the switch and signal bus bars being used exclusively for out going currents from the battery. As will shortly be explained, incoming currents from another source of electric energy pass through the indication bus bar.

There are two control wires, known as the normal and the reverse control leading from the interlocking machine to the motor in the switch machine.

When the leverman commences to reverse his lever, its stroke is arrested as already described by the indication dogs until the indication magnet is energized, but it is completed far enough to close the circuit through the reverse control wire and one set of field coils in the switch motor. This starts the motor shaft revolving and through the gearing revolves the main gear b in the direction of the arrow in the sectional view of the switch machine in Fig. 73.

The action of the cam crank is very similar to that of the escapement crank in a mechanical switch and lock movement, that is, the first part of the movement of the main gear does not move the crank arm. The crank pin, however, being rigidly fastened to the side of the main gear commences to move the connecting rod, and through it the three arm crank, at once, thereby raising the detector bar and withdrawing the locking plunger from engagement with the lock rod and throw rod of the switch. In passing, it may as well be noted, that with this switch movement, the detector bar does not go entirely over. It is raised up by the three arm crank and then drops back on the same side of the vertical from which it came up. After the locking plunger is withdrawn,

the crank pin engages the cam end of the cam crank and throws the switch points, after which the crank pin ceases to move the crank arm, but still, through the connecting rod, moves the three arm crank so as to lock the switch reversed and drop the detector bar. As soon as this is accomplished the crank pin engages the semi-circular corner of the cam slot, shown as X, which stops the further progress of the main gear in the direction in which it is then moving. This does not, however, stop the motor, because the motor shaft is divided and is held together by a friction clutch which slips as soon as the further motion of the main gear is checked. The action of the pole changing switch as the track switch was reversed has been such as to cut the current from the battery off from the field coils of the motor.

Now as stated in the commencement of our consideration of power interlocking, a motor while revolving is generating a small amount of electric current in opposition to the current which is being supplied to run the motor, which fact is utilized here to operate the indication. The battery current having been shut off from the motor by the action of the pole changing switch and pole changer, does not instantly stop the motor, because it has acquired enough momentum to continue revolving for some little time, and is thereby generating a current of an opposite polarity (flowing in the opposite direction) from the current which operated the motor.

The action of the pole changer has been such also as to close a circuit by which this current which is being generated by the motor may flow back toward the machine along the wire which a moment before was the normal control wire. This current flows back through the indication magnet to the indication bus bar and from thence to the indication common wire by which it finds its way back to the negative

pole of the switch motor, acting temporarily as a dynamo.

This is known as a *dynamic* indication current, as distinguished from a battery current. It is peculiar to the type of machine we are now discussing.

Signal mechanisms also vary greatly from any we have yet discussed.

In every variety of all electric interlocking there is always a possibility that wrong currents may pass through a wire. This may happen from various causes. Two wires, one of which is already carrying a current from the battery, may touch each other, so that the current may divide and part of it go through each wire, or a wire carrying a current from another source, such as a telephone, telegraph or trolley wire may touch earth or some other conductor which will make a connection between it and one connected with the interlocking plant not at that time intended to be in circuit.

Troubles from the first cause are called crosses, and from the latter, interferences by foreign currents.

Where plants are near power houses or lines of electric railways or lighting plants, currents of very high pressure are often found going through the earth, part of which may leave it and run through any wire which touches the earth, provided the current can find a path out again. These are called earth currents.

To have any wrong current of this sort come through an indication magnet or start a switch motor when the leverman did not intend it should be started might lead to very serious trouble, so that the utmost precautions must be taken to prevent such action by these false currents.

It is for this reason that the safety magnet already alluded to is introduced. The current from the battery which operates the switch motor is made to pass

through this magnet, which is placed immediately beneath the indication magnet in such a way that the armature of the indication magnet rests on the end of the cores of the safety magnet. Now if a current is flowing through either control wire this safety magnet is energized and, therefore, holds down on the armature of the indication magnet with much greater force than the indication magnet can exert to pull it up. After passing through the safety magnet the battery connection is divided into the normal and the reverse control wires. Each of these passes through another separate magnet. These have a common armature and taken together and with the armature form what is known as the indication selector. When the lever is reversed the reverse control circuit is closed, and not only the safety magnet, which is common to both normal and reverse control wires, but also that one of the indication selector magnets which is in the reverse control circuit, are both energized. The energizing of the selector magnet attracts the common armature toward it. This armature is arranged as a lever, being hinged at one end. The free end plays between two contact points. When it is attracted toward one of its magnets, it touches one of these contact points, and when it is attracted toward the other it leaves the first contact point and touches the second. These contact points are made part of the normal and reverse indication circuits. The hinge of the armature is connected to the indication magnet. Now when the battery current flows through the reverse control wire that magnet is energized and its armature closes the reverse indication circuit, ready to receive the indication current just as soon as the pole changer at the switch machine acts. If, however, foreign current is flowing in the normal control wire, the instant the pole changer breaks the circuit through the reverse control wire the common

armature is pulled away from the magnet in that circuit by the magnet in the normal circuit, and the reverse indication circuit is broken, so that nothing but the proper current can effect the indication.

In addition, also, so-called fuses are let into the control circuits. These fuses are short lengths of fine fusible wire. It is a fact that when the pressure of a battery or generator is forcing current through a conductor of high resistance, the current tends to heat the conductor. The fuses are so arranged that in case a switch should stick or the points become blocked, and the friction clutch should fail to slip, the increased current which will be poured in from the battery to the motor will so heat the wire that

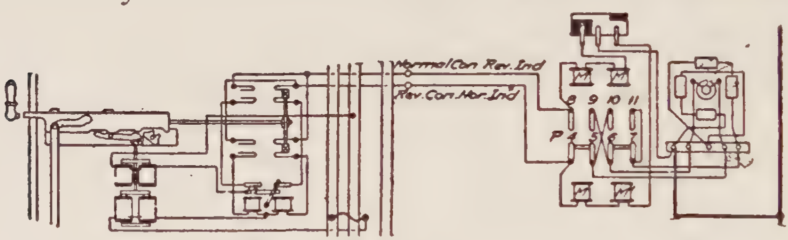


Fig. 75.

it will fuse or melt away, thus automatically opening the circuit and preventing the increase of current from heating the magnets or field coils to such an extent as to burn the insulation off the wires and ruin them.

Fig. 75 shows a switch lever, indication and safety magnets, indication selector, switch machine and connections, in a diagrammatic way, which will no doubt aid the reader in tracing out the foregoing description. Even with all the safeguards just described the reader can no doubt, if he gives the matter enough study, devise a combination of crosses which might give a false indication, but the possibilities of such happening in actual practice are so very unlikely as to be considered outside of the calculation.

High signals as made at present usually have the operating machinery in a case at the base of the pole, which is virtually an enlargement thereof. In the earlier design the operating machinery was placed in a separate case attached to the side of the pole. As a great many signals so constructed are still in service, I shall take space to describe both designs. The former is known as an inside connected signal, and the latter as an outside connected signal. As the latter was the earlier design we shall describe it first.

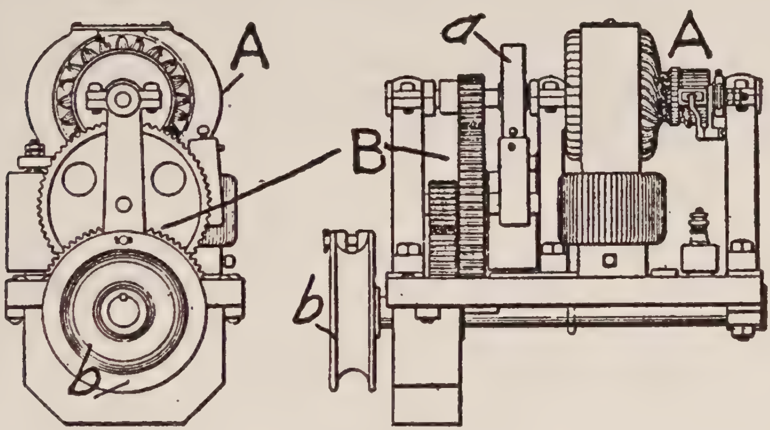


Fig. 76.

Fig. 76 shows a side and end view of a signal machine for an outside connected signal. A is the motor, B the system of gearing, much like that in a switch machine, terminating in a chain wheel b to which a chain is attached, the other end of which is fastened to the balance lever on the signal pole from which the up and down rod leads to the arm plate. For one arm signals the motors supplied are not reversible, for two arm signals they are. With a one arm signal one wire runs from the machine to the motor. The action of the motor clears the signal, which is restored to normal by the counterweight. A magnetic brake shown as a in the figure is pro-

vided and so arranged that when the signal arm has reached the full clear position a circuit controller attached to the up and down rod and operated by it, switches the current from the motor to the coils of the brake magnet. This causes the brake shoe to bear on the brake wheel and stop the motor very quickly. The chain is attached to the counterweight lever by a spring jaw, shown in Fig. 77, which allows the motor to over run a few turns without being suddenly brought up by the arm plate coming in contact with its stop. Current is kept on the brake

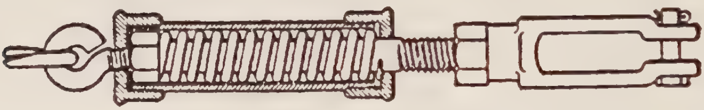


Fig. 77.

magnets while the signal remains in the clear position. Their coils are so constructed as to have a very high resistance, thereby drawing a minimum of current from the battery while the signal is clear. When the leverman returns the lever to normal the circuit through the brake coils is opened, the brake lets go, and the counterweight not only throws the blade to normal, but acting through the chain on the chain wheel, spins the shaft of the motor around in a direction opposite to that in which it revolved when winding up the chain in order to clear the signal. As stated when we commenced discussing power interlocking, a motor revolving in a reverse direction becomes a dynamo. As soon as the signal blade, therefore, reaches its normal position the control wire circuit is closed through the circuit controller on the up and down rod, but being shifted to the indication circuit by the circuit controller at the lever, the dynamic current generated in the motor flows through the indication magnet, energizes it, and re-

leases the lever so that its stroke may be completed. Two bladed signals of this type are generally selected by a circuit controller, called a *switch box*, or selector, attached to the points of the switch. The common wire from the lever runs to this switch box, where, if the switch is normal, it is connected to a wire running into one set of field coils in the motor, and if the switch is reversed, it is connected to a wire running to another set of field coils. The first set will revolve the motor one way and the second set will revolve it in the opposite direction. The chain instead of being pinned to the chain wheel, as with the single blade signal, passes over it, where it is prevented from slipping by sprockets. One end of the chain is fastened to the counterweight lever of the upper blade, and the other end to the counterweight lever of the lower blade. Now if the motor revolves in one direction it will by the sprocket in the rim of the chain wheel pull up on one end of the chain and slack away on the other. It will, therefore, raise one counterweight lever but leave the other one down. The indication current is generated in the same manner as described for a single blade signal.

Where more than two blades on one mast are to be operated by one lever a special hook selector is attached to the mast. The motor then used is the same as for a single arm signal. The chain is attached to an operating lever much like a counterweight lever. This is keyed to a shaft on which the counterweight levers are also pivotted, but are not keyed thereto. Outside of the last counterweight lever a so-called *short operating lever* is keyed. These two operating levers are connected by a *latch bar*. Over each of the counterweight levers is a pair of electro magnets coupled together to act on an armature which is bent around so as to form a hook. When any one pair

of magnets is energized it attracts its armature, the hook of which engages the latch bar. The switch box selects the pair of magnets to be energized.

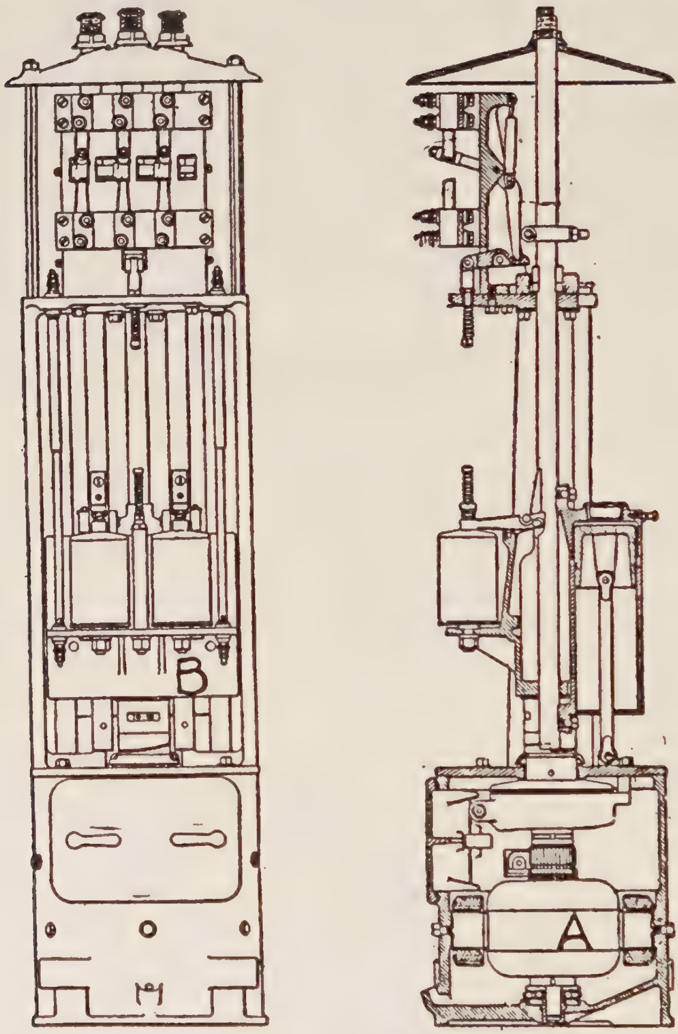


Fig. 78.

The chain from the motor is attached to the long operating lever, which, on being raised by the chain, brings with it that one of the counterweight levers whose magnets happen to be energized at the time.

At the switch box the different magnet circuits as they are called in play are connected to the common wire. In this way the current goes out to the magnet first and returns by way of the switch box.

The mechanism for an inside connected high signal is shown in Fig. 78.

The motor A is so placed that its shaft stands vertically. This shaft turns a screw which shoves up on the cross head B. This cross head is connected to the up and down rod so that when it is shoved up the arm plate of the signal is brought to the clear position. Its movement also mechanically operates circuit controllers by which the battery current is switched from the field coils of the motor through high resistance magnet coils operating a brake which bears on the motor shaft, holding the signal at clear.

When the leverman returns the lever to normal, circuit through the brake magnet is opened; it releases its armature, thereby relieving the pressure of the brake shoe on the shaft. The weight of the cross head pressing down on the thread of the screw spins the motor shaft, and with it the motor armature, around in the direction opposite to that in which it turned while setting the signal at clear, thereby generating the indication current.

In the case of a two or three bladed signal the selection is done through a switch box, the circuits from which are carried through magnets in the motor case. These magnets are attached to the cross head and move with it. When energized their armatures operate hooks, much like those in an ordinary mechanical selector, which engage notches in the lower ends of the up and down rods. Thus the movement of the cross head is transmitted to that one of the up and down rods which is hooked to it at the time.

Before describing the dwarf signal movement used with the General Railway Signal Company's apparatus, it will be necessary to explain that if the core

of an electro magnet is loose in the coil and is, while the coil is de-energized, partially withdrawn, the coil will when energized act on the core as a magnet and tend to pull it completely back into the opening through its own center. In this way the core may be made to perform the same work as is performed by the armatures of such magnets as we have discussed heretofore, and a considerably longer stroke can be had. Such an arrangement is known as a *solenoid.*

The General Railway Signal Company's dwarf signals are operated by solenoids instead of by motors. The magnets of these solenoids are placed inside the mechanism case of the signal and encircle tubes inside of which the cores, which are attached to the cross head move. A shaft from the upper side of the cross head terminates in a rack, which engages a pinion keyed to the spindle to which the arm plate is also attached, so that the up and down movement of the cross head imparts a rotary movement to the spindle, thereby operating the arm plate.

Sliding circuit controllers much like those used with the electro pneumatic signal serve to switch the battery current from the solenoid coils to the indication circuit when the signal is returned to normal. These dwarf signals, therefore, use battery and not dynamic current for their indications.

In the operating room of each tower is placed an *ammeter,* which is an instrument to gauge the number of amperes of current being used at any particular time, and a *voltmeter,* which is an instrument to gauge the pressure in the battery at all times, just as a steam gauge is used to gauge the pressure of steam in a boiler.

When a plant is in good order and no current is being lost through leaks the ammeter should register zero, except while a switch is being moved or a signal

is at clear. The voltmeter should register approximately 110 volts at all times, except while the battery is being charged when it will register much higher. If it falls much below that point it is an indication that the battery should be charged at once.

A *power board* is placed in the room with the dynamo. This is also provided with an ammeter, a voltmeter, with incandescent lamps which light up in case of leakages, and with safety switches which throw themselves automatically and break circuit in case such an amount of current as would endanger the magnet coils by overheating them should chance to get into one or more of the circuits. These power boards are not peculiar to interlocking plants, and they are in all essential details similar to those used at any power station.

CHAPTER XV.

OTHER TYPES OF POWER INTERLOCKING.

Before entering on a description of the Union Switch and Signal Company's all electric interlocking apparatus, there is another point in regard to the application of electric currents which I shall call to the reader's notice.

Heretofore we have considered only direct current electricity, by which is meant electricity which flows always in one direction.

Certain types of generators or dynamos are so constructed that they give forth a current which flows first in one direction and then in the other. That is, what would be the positive pole in a direct current generator becomes in an alternating current generator first the positive and then the negative, and the negative pole is also first negative and then positive. The transition from one to the other is very rapid. The direction of the current is changed as often as 200 times a second. Instruments known as *transformers* are manufactured, which will either raise or lower the pressure of an alternating current, but as the principles by which such instruments perform their function belong more to electrical science than to railway signaling, I shall not go into them here. The reader who wishes to pursue this subject further will find it fully explained in any treatise on alternating current apparatus. When the pressure of a current is raised by a transformer it is said to be

stepped up, and when it is lowered, to be *stepped down.*

Where in a discussion both direct and alternating currents are being mentioned, it is customary to write the initials D. C. and A. C. after the description of the current, as 110 volts D. C. or 110 volts A. C., as the case may be.

Where only direct current is being considered in a discussion these initials are omitted.

With alternating currents it is customary always to retain them.

The machines used with the Union Switch and Signal Company's all electric interlocking are very similar indeed to those used with the electro-pneumatic. The contact strips and battery strips being intended to carry currents under an electric pressure of 110 volts are made much heavier than those for the electro pneumatic machine, which carry current under pressure of only 10 to 15 volts.

The indication jaw is not operated directly by an indication electro magnet as in the electro pneumatic machine. It is attached to a centrifugal device very much like the familiar governor of a stationary engine, consisting of two stems terminating in comparatively heavy balls and hinged at the other ends to a vertical shaft. When this shaft is revolved rapidly the balls have a tendency to separate, caused by centrifugal force. At rest the stems form a figure like the two sides of a triangle, but on being revolved rapidly they move into a horizontal straight line through the apex of the triangle, thus raising the balls and the jaw which is attached to them and releasing the indication segment. The stems and balls are attached to the shaft of a small alternating current motor placed in the back of the machine and so arranged that its shaft is vertical. In front of this motor is a transformer, which in turn is connected by proper

wiring, which will soon be explained, to the switch or signal moving machinery.

The switch machine consists of a motor, the shaft of which, through the medium of a reducing gear, revolves a cam screw. The reducing gear is so arranged that twenty-five revolutions of the motor give one revolution to the cam screw. The main shaft is divided and its parts are held together by a clutch, the two parts of which are forced against each other by electro magnets, and is, therefore, known as a magnetic clutch.

The spiral around the cam screw engages rollers attached to the ends of one arm of each of two separate cranks. The other arm of one of these cranks is attached by a special switch adjustment to the head rod of the switch. The outside arm of the other crank is attached to the detector bar, and the same arm which engages the cam screw is attached to a slide plate which extends beyond the end of the main shaft and carries the locking dogs, which engage the lock rod attached to the switch points. The motor is so arranged that after a switch has made its complete travel and is locked, the clutch releases and the driving current is switched to another circuit (still operating the motor) in such a way that instead of being a current of uniform pressure it pulsates. When the lever is reversed current from the battery, which is, as with the General Railway Signal Company's machine, a 110 volt storage battery, is supplied to the motor and starts it revolving, carrying with it the cam screw. This moves the slide plate carrying the dogs, and unlocks the switch, at the same time throwing the detector bar all the way over. Next the switch is thrown while the points are not locked, and lastly the reverse locking dog engages the lock rod the same as with any other type of switch and lock movement. As soon as the switch is over and locked a

circuit controller, mechanically operated by the switch and lock movement, switches the circuit through the motor as above described. As long as the current in this circuit was of uniform pressure it had no effect on the transformer through which it is carried, but as soon as it becomes a pulsating current it produces a perfect alternating current in the other side of the transformer. This secondary current is carried through the indication motor and starts the latter motor revolving, thereby through the governor-like apparatus already described, releasing the indication segment. The leverman then completes the stroke of the lever, thus breaking the circuit through the switch motor, which stops revolving.

As in the General Railway Signal Company's machine, one common control wire and one common indication wire are carried through each plant, and there are two control wires to each switch movement which also serve as indication wires. The feature of an alternating current indication has been introduced to prevent the possibility of any stray direct currents, which might get on the indication wires from crosses with other wires or grounds, giving a wrong indication. A direct current of uniform pressure passing through the transformer will have no noticeable effect on the indication motor.

The high signals used with this type of interlocking are differently constructed from any yet described, and as a signal constructed on the same principle is used for many other purposes connected with interlocking and block signaling, we shall take space to describe it fully.

Fig 79 gives a view of the mechanism of one of of these signals and also three separate views of the slot arm which is the most unique part thereof.

It will be noted that two slot arms are shown in the view of the full mechanism. This is for a two

arm signal. With a one arm signal only one slot arm is necessary. For purposes of illustration, it is convenient, however, to show one arm inclined upward

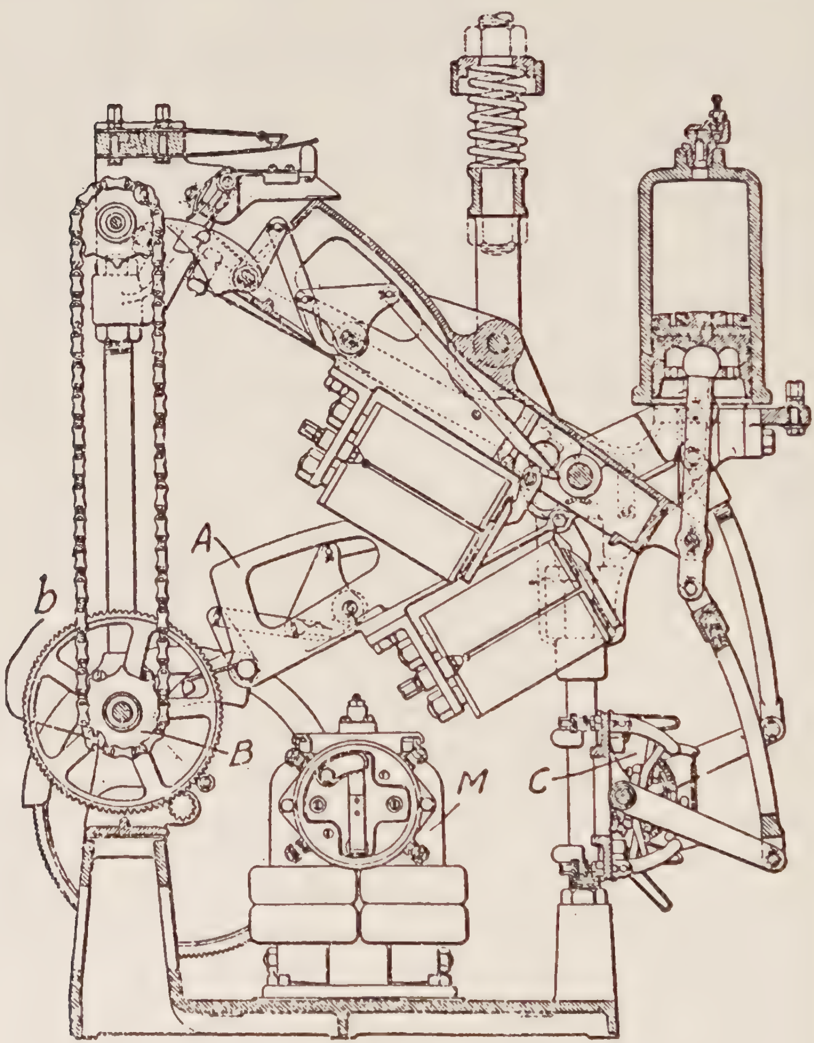


Fig. 79.

and one downward so the two arm mechanism has been used in the illustration.

M is the motor which is put in motion when the

leverman reverses the lever and through suitable gearing revolves the sprocket wheel B. This winds up

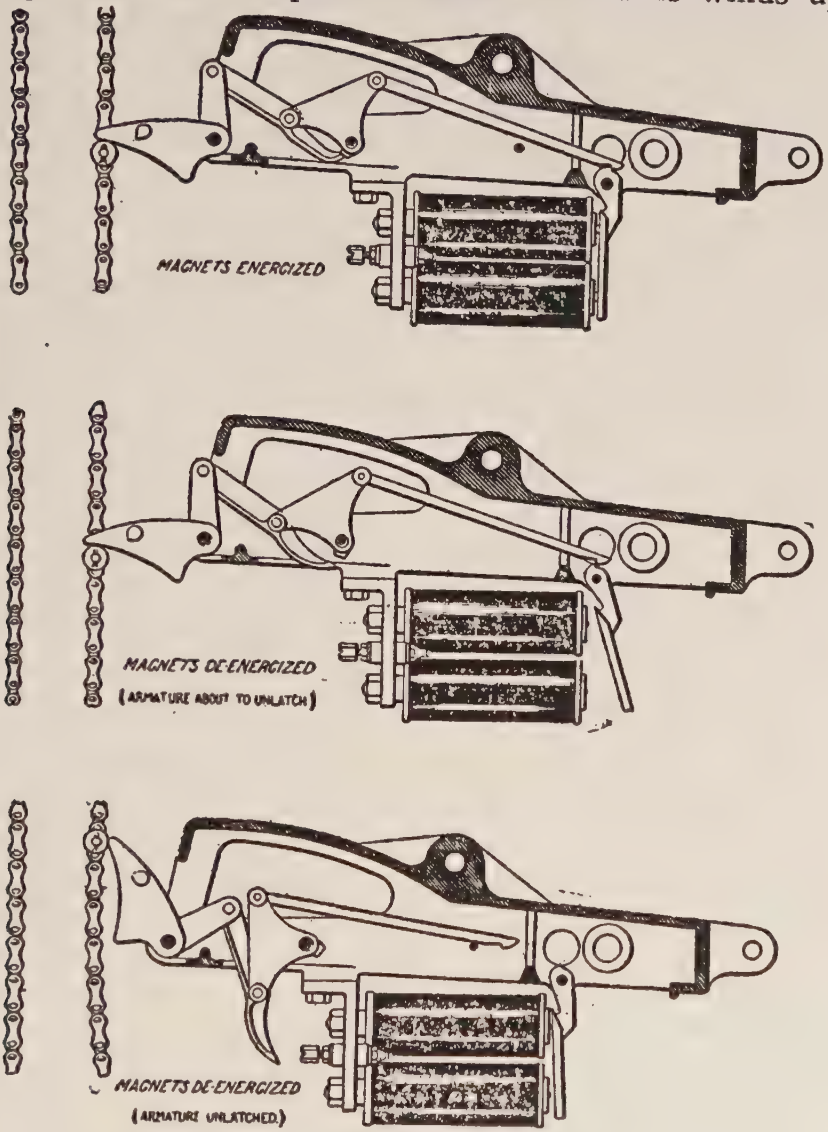


Fig. 80.

on the endless chain which passes around it. In this endless chain is a pin "b," which engages a forked head at the end of the slot arm A. C is the pole

changer or circuit controller. When the signal is normal this pole changer connects one set of field coils in the motor in series with the coils of the slot magnet, so that the slot magnet is energised and the forked head of the slot arm is held rigid. This is easily seen by reference to Fig. 80, showing the slot arm in detail. When the motor revolves, therefore, and winds up the chain, it raises the end of the slot arm, which in turn pushes up on the up and down rod and clears the signal. On going to its full clear position the signal shifts the pole changer so as to cut current off the motor and also switch it through a high resistance coil of the slot magnet. Although the figure does not show it, it should be understood that the slot magnet is really two separate pairs of magnets wound about the same cores. That in series with the motor is low resistance so as not to reduce the amount of current going to the motor coils, and the other, through which, as just stated, the current is switched when the signal is at full clear, is of high resistance so as to use up a minimum of current while the signal stays at clear.

The signal motor like the switch motor has two sets of field coils, one to make it revolve in one direction, the other to reverse that movement. When the leverman returns the lever to normal, current is cut off from the slot arm magnet, its armature is released, unhooking the latch of the slot arm, which in turn releases the forked head, allowing it to bend backward as illustrated in the figure. This lets that end of the slot arm which is being borne down by the weight of the up and down rod and the arm plate, drop down, allowing the signal to return to normal. When the slot arm is in its full down position the forked head falls forward by gravity, thus placing the hook, which is hinged to it, over the armature

of the slot arm magnet in such a way that as soon as that magnet is again energised the hook will hold the forked head rigid.

As with other types of power interlocking, the signals indicate from the normal position only.

Current for the signal indication is generated by a transformer in exactly the same manner as with a switch machine.

An air dash pot, much like the air cushions put on doors, prevent the signals dropping back to normal too violently.

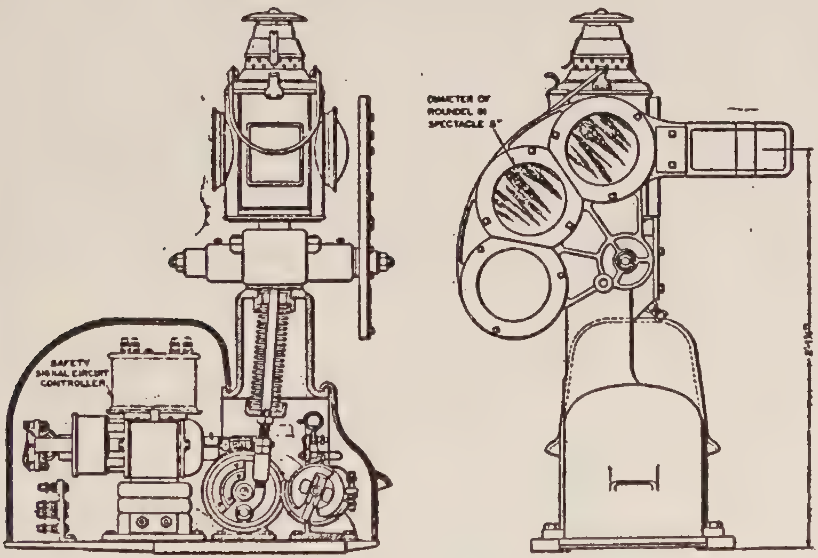


Fig. 81.

The dwarf signals used with the Union Switch and Signal Company's all electric, or at least that type of it now under discussion, are operated by motors, but are not provided with a slot arm. The motor through proper gearing, readily understood from Fig. 81, which shows a sectional view of one of these signals, shoves the arm plate to clear against the action of a coil spring. This spring acts as a counter weight to restore the signal to normal. The

arm plate is held in the clear position by a magnetic brake of high resistance through which the battery current is switched from the motor.

In addition to the one which we have just been describing, the Union Switch and Signal Company has recently put out an all electric interlocking, some parts of which, more especially the machine, are of an entirely different design. Although this is of a very recent appearance and may yet be altered in some of its details, we will say a few words about it here. The levers in the machine are arranged to be pulled outward and then pushed downward when being reversed. The hand hold is a good deal like the stock of a pistol. The levers operate quadrants, and the feature of latch locking mechanically applied is a part of their operation. Like the low pressure pneumatic these machines are so constructed that the stroke of the lever is automatically completed by release of the indication. This by the way is a feature which may be applied to the Union Switch and Signal Company's other type of all electric machine, although rarely done. The indication current for switch movements and high signals is derived in a manner exactly similar to that already described for this Company's other type of all electric machine. It is stepped up, however, from 110 to 220 volts pressure. The dwarf signals are of the solenoid type and indicate by switching the battery current over, much as is done by the General Railway Signal Company's dwarf signals. The switch levers are provided with latch circuit breakers to be used in connection with *detector circuits,* a discussion of which we are reserving for a later chapter. The locking is of the vertical type. The switch and high signal movements are in all essentials identical with those described as used with this company's earlier all electric interlocking.

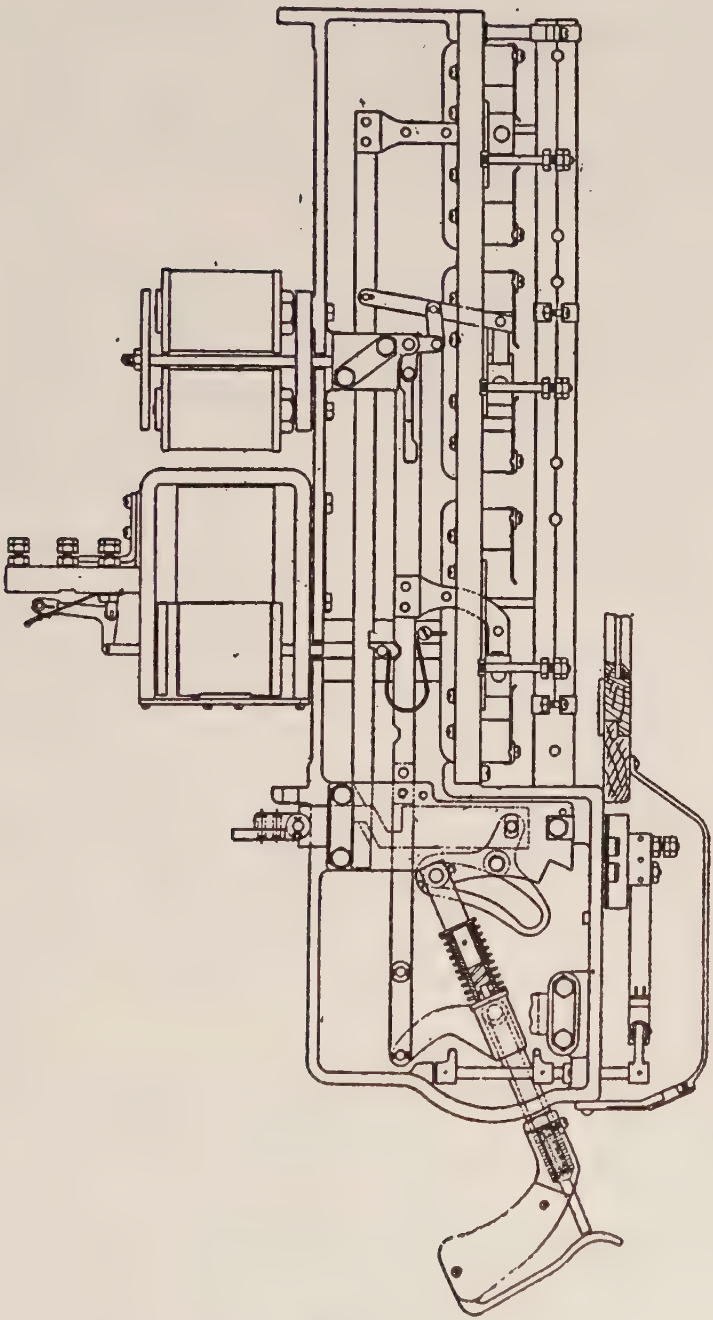


Fig. 82.

The dwarf signals are, as just stated, of the solenoid design.

Fig. 82 gives a section through one of these machines, from which the reader will easily discern the principle points of difference between it and the other types we have met with so far.

The Federal Railway Signal Company's all electric interlocking is the next type we shall consider.

There is a radical difference between it and any of the foregoing, with respect to the machine used.

The Federal machine is a miniature Saxby and Farmer machine throughout — levers, quadrants, latches and all, and the feature of latch locking appears in this machine just as it does in one designed for a mechanical plant.

The operating contacts are made much as they are in the electro pneumatic or Union Switch and Signal Company's all electric machines of the vertical roller type. The vertical rollers are in the front of the machine frame, however, and two good strong bus bars are placed below them.

The indication magnets are fitted into a cast iron frame so that it is impossible to reach under them and push up the armature of the indication magnet as may be done with the General Railway Signal Company's all electric machine, if the glass cover of the case enclosing the locking and circuit breakers is removed.

The mechanical operation of the indication magnet is to have its armature when the magnet is energised bear on one end of a latch in such a way that the other end will be depressed. This latch is attached to a bar which is in turn attached to the lever and slides backward and forward in a horizontal plane as the lever is set normal or reversed. The end of the latch which is not acted on by the armature is provided with a knob or dog which, when the magnet is de-energised

and the armature down, engages a steel bar extending along the entire front of the machine, under and parallel to the front of the locking bed. The reverse indication acts in the opposite way.

The indication magnets are energised by battery current.

The switch movements are a screw arrangement operated by a motor somewhat similar in general principles to those furnished with the Union Switch and Signal Company's all electric interlocking. The screw is not a cam but a regular screw and its outer end is attached to the slide bar of an ordinary switch and lock movement. The battery current is switched from the motor to the indication circuit by a pole changer, mechanically operated by the movement of the switch and lock movement. The motor is stopped by a magnetic brake and its shaft is held together by a magnetic clutch which slips in case something prevents the switch or detector bar from moving when current is sent through the motor. Fuses are provided in the machine as well.

There is no vital difference in the wiring arrangement between this and other types of all electric interlocking. At the present writing it is understood that this company is engaged in perfecting another design of switch machine and is also contemplating a change in its method of generating its indication current.

The signal machines are simple, a motor operating through gearing and hold clear magnets of high resistance to hold the signal after the motor is stopped. Both home and dwarf signals depend on gravity to restore them to normal.

The American Railway Signal Company's machine is so constructed that the levers are shafts with handles, something like those of the General Railway Signal Company's machine. In reversing they must

first be given a sidewise twist and then pulled out toward the leverman where they are stopped at the end of the stroke with the locking, which is of the Saxby and Farmer type, uncompleted until the indication is received. The effect of the indication is to give the shaft a further sidewise twist, thus completing the stroke of the locking bar. In the return to normal the process is reversed. Like the low pressure

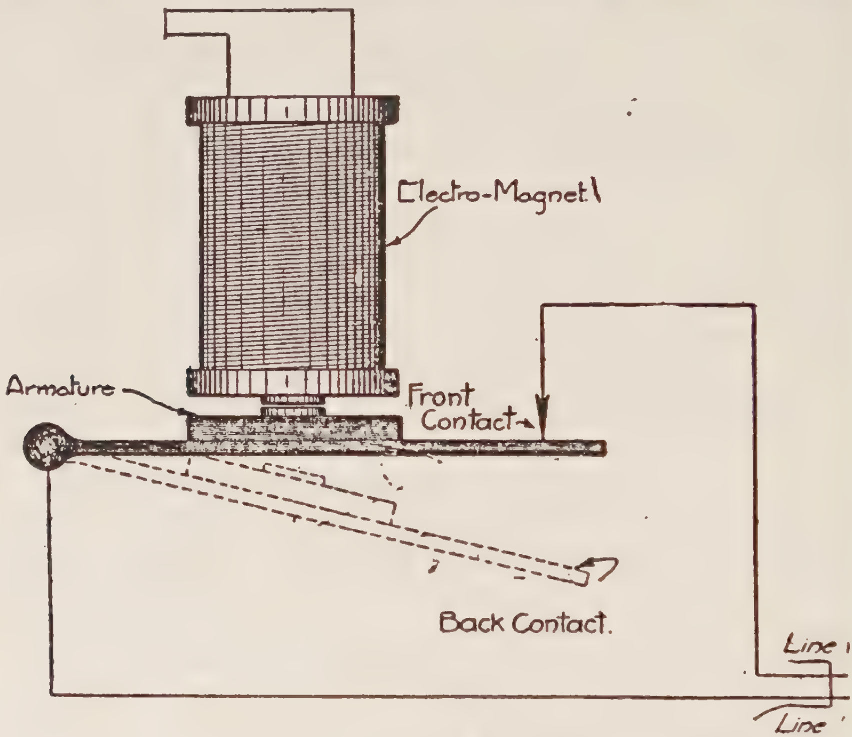


Fig. 83.

pneumatic and latest type of all electric machine of the Union Switch and Signal Company, the indication completes the stroke of the lever automatically.

The indication current is furnished by the battery. The indication magnet is a solenoid. Circuit through this solenoid is broken through the front contact of a *relay*. A relay, about which device we shall hear

a great deal further on, is an electric magnet whose armature is attached to a small lever made of a low resistance material. This small lever is hinged at one end and free at the other to play between two bearings. When the magnet is energized so as to attract its armature the relay is said to be "picked up." When the magnet is de-energised so that the armature, which is always underneath the magnets, has fallen away from the end of the cores, it is said to be "down." When picked up, the free end of the lever bears against one of the bearings, but does not touch the other. This bearing is called the *front contact.* When the relay is down the lever bears against the other bearing, called the *back contact,* and does not touch the front contact.

Fig. 83 shows a relay diagrammatically, with the contact points indicated. It is easily seen that if a wire leading from one pole of a battery is attached to the hinge of the lever and a wire leading from the other pole is attached to the front contact point, that every time the relay is picked up the circuit will be closed and current will flow. When the relay is down the circuit will be open. As before stated with the interlocking machines we are now discussing the circuit through the solenoid is broken through the front contact of a relay. This relay is normally down.

The current to pick up the relay is furnished by an *induction coil.* This is an arrangement by which a coil of insulated wire is wound around the outside of the coil of an electro magnet. Every time the electro magnet is energized a current is sent out from the outside coil which is connected with the relay. By using a low resistance coil for the electro magnet, which is called the *primary coil,* and a coil of a great many turns of fine wire for the outside coil, which is called the *secondary coil,* a great difference in the

electric pressure in the operating current which goes through the primary coil and in the *induced* current which is generated in the secondary coil, is effected. The induction coils used with the machine under discussion send a current of 5000 volts pressure. The circuit through which this current works is always open, but a current under as high a pressure as 5000 volts will jump across a small gap such as is left in the circuit, just as we often see the current in a street car trolley wire jump across to the trolley pole when the latter, after having slipped off, is being put back in place by the conductor of the car, and before the two have come together so as to make a perfect contact.

As this high pressure current is only in use momentarily and the parts of the machine through which it passes are well protected, its use is not considered dangerous.

The presence of this gap prevents any low pressure currents which may get on the indication wires by crosses or from other causes from going through the relay and picking it up at the wrong time, as they have not force enough to jump the gap. The indication coil is placed in a neat cast iron box near the switch movement.

The switch movement itself consists of a 110 volt motor which drives a shaft. This shaft has a pinion keyed to it about half way between the motor and the end of the shaft farthest away from the motor. This pinion engages a rack working at right angles to the shaft. This rack is attached to the head rod of the switch by an ordinary special switch adjustment. A cam screw is attached to the end of the shaft farthest from the motor which operates the detector bar and lock. A circuit shifter or pole changer is also operated by the lock movement which switches the battery current through the primary coil of the induction coil when the switch is over and locked.

The high signal motors are arranged to wind up a chain which is attached through a bronze rod to a segment to which the spindle of the arm plate is keyed. The signals are, therefore, pulled to clear. The arm plates are very heavy and act as a counterweight to restore the blades to normal. The dwarf signal mechanisms are much the same as those of the high signal. As this company manufactures an automatic block signal on exactly similar lines to its interlocking signal we will reserve a more detailed description for a later page.

The reader may perhaps wonder by this time why there are so many different designs of power interlocking in use, all aimed to accomplish the same end, namely, to throw and lock switches and movable frogs and to throw signal blades.

There is only one answer to such a thought. Power interlocking having become a practical possibility comparatively recently, the patents on the various apparatus used still hold. Each manufacture is desirous of being able to furnish the railroads with all sorts of interlocking and signaling devices. As certain patents are held by each manufacturer to the exclusion of the others, each has been forced to develop power interlocking machinery of his own.

No doubt when power interlocking has reached the same condition in which mechanical interlocking is found today, where any manufacturer may build apparatus in all important particulars exactly similar to that built by the others, the Railway Signal Association will narrow its specifications for power interlocking to a point where but one style of apparatus will be manufactured by all makers. The power plant of the future will no doubt embody the best features of the several designs now used, with the addition of such improvements as will from time to time suggest themselves. To a certain extent it is

a pity that some of the energy now being expended in developing new types of power interlocking cannot be applied to improving designs already in use.

At present, and for some time to come the signal engineer must face conditions as they exist and must use his best judgment in selecting the type of apparatus best suited to his needs.

Any one of the six designs described will do the work required of it, if well installed in a satisfactory manner.

From the signal engineer's standpoint it is always objectionable to have too many designs of apparatus under his supervision, as it requires the carrying in stock of a much greater quantity of repair parts than would be the case if only one type was used.

A zealous critic may easily find fault with any system yet invented, nor is it likely that an absolutely perfect apparatus will ever be designed.

The electro pneumatic has done good work for many years, but the cost of supplying compressed air where a source of supply is not already provided makes it very expensive to operate.

The facility with which the indication magnets may be tampered with in the General Railway Signal Company's all electric is objected to by some critics, and so on through the list.

Power interlocking has a large field of usefulness, but it is not likely that for many years to come it will entirely supplant the mechanical apparatus.

A very good rule to follow is never to use a power plant where a mechanical plant will do the work. That is, if all the switches to be operated are within a radius of seven hundred feet from some central point where the tower may be conveniently placed, and the traffic conditions are such that the levers do not have to be moved so frequently that the physical strain on the leverman becomes so great that frequent

shifts of men are required, a mechanical plant will, in most cases be found much more economical to maintain and fully as satisfactory to operate.

It will, even as a general thing, pay to spend considerable money in rearranging tracks and switches so as to bring them within the reach of a mechanical plant, where the traffic conditions will warrant using one.

The introduction of power interlocking has developed a tendency to attempt to extend the limits of interlocking plants so far that it becomes impossible for a leverman to control train movements as he should, and in that respect has sometimes over-reached itself, even to the point of occasioning serious delays in the movement of trains.

After a few general remarks on the installation of power interlocking we will take up the subject of arranging interlocking for specific cases, and the preparation in connection therewith of locking and dog charts.

In all power interlocking the wire used should be copper. That which is to be placed in trunking or any other conduit should be either in the form of a cable or the wires should be insulated with a rubber preparation over which one or two thicknesses of braid should be wound. Some signal engineers insist on a coating of the rubber preparation 5-64 of an inch in thickness; others are satisfied with 3-64 of an inch. Lead covered cables are not to be recommended.

There is room for a good conduit which is not easily broken, may be kept above ground and affords easy means of opening it up to take the place of the wooden trunking usually used, but no satisfactory substitute has yet been brought out.

Care should be taken to avoid jointing wires inside of conduit. Junction boxes which, as already men-

tioned, are small terminal boards provided with binding posts may be used very conveniently wherever wires are led from the main line to a switch or signal.

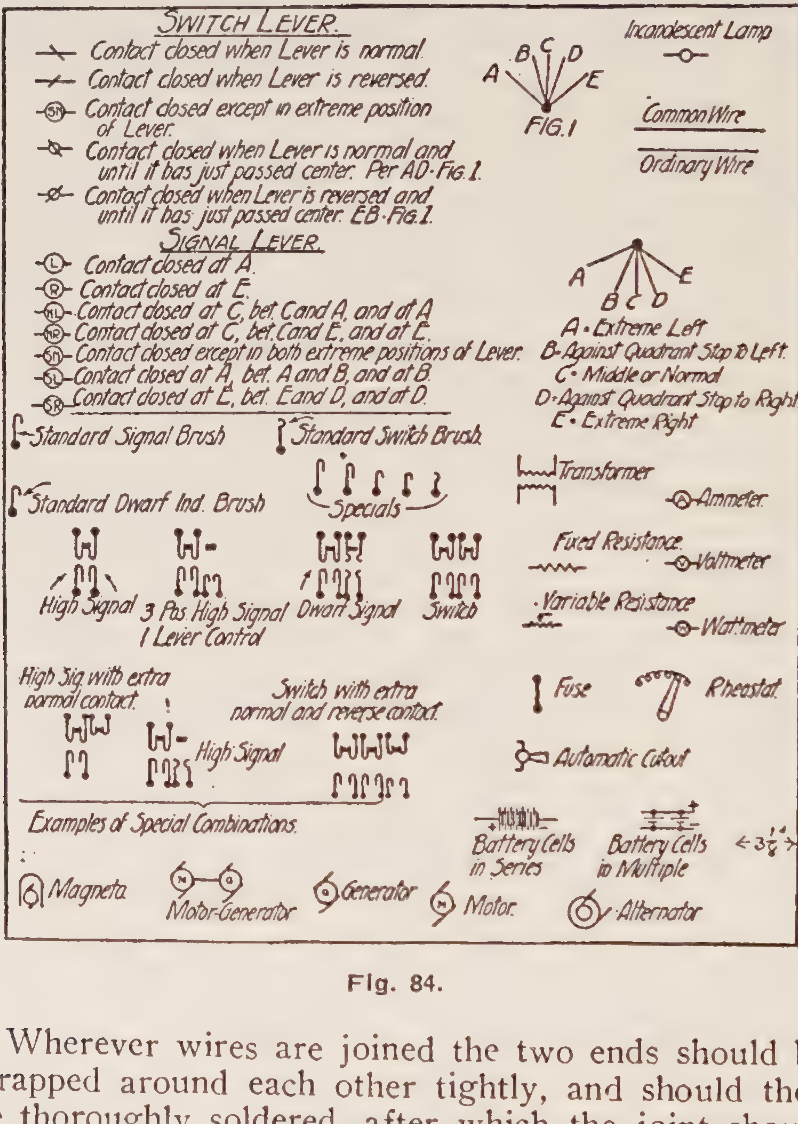


Fig. 84.

Wherever wires are joined the two ends should be wrapped around each other tightly, and should then be thoroughly soldered, after which the joint should be well wrapped with adhesive tape covered with cotton braid tape. Care should always be taken to

cut off the outer braid from the wire, leaving the rubber insulation exposed for from half an inch to one inch on either side of the joint. This will allow the adhesive tape to take hold of the rubber covering of the wire, which makes a much tighter joint than if the braid is allowed to get under the adhesive tape. Care should be taken to get all wires large enough. Tables are to be had showing the size wire Brown and Sharpe gauge to be used for currents at different pressures and different distances. At interlocking plants it is well to stand on the safe side and use wire a size or two larger than the tables call for.

There are so many good storage batteries and generators on the market that very little need be said on that head, except that the battery should be of large enough capacity to run ten days on one charge if possible.

Fig. 84 is a table of the conventional signs used on drawings to denote the different apparatus used with power interlocking.

CHAPTER XVI.

LOCKING AND DOG SHEETS.

After it is decided to build an interlocking plant, at a given point on a railroad, and the track plan, described in an earlier chapter, has been prepared, it becomes necessary to prepare other plans from which the mechanics who build the interlocking machines can work in order to have the proper locking in the machine. The first step is to draw up a list of the necessary locking for each lever to perform. This is called the *locking sheet* or *locking chart*. It is simply a list of the levers in the machine, showing what locking each accomplishes *when it is reversed*. For instance, the locking sheet of an eight lever interlocking machine might read as follows:

Lever No. 1 when reversed locks Lever No. 2, reversed.

Lever No. 2 when reversed locks Lever No. 3, reversed, and No. 7 normal.

Lever No. 3 when reversed locks Lever No. 4, normal.

Lever No. 4 when reversed locks ...... (see note).

Lever No. 5 when reversed locks Lever No. 4, reversed, and No. 6, normal.

Lever No. 6 when reversed locks Lever No. 4, reversed (see note).

Lever No. 7 when reversed locks Lever No. 3, reversed (see note).

Lever No. 8 when reversed locks Lever No. 7 reversed (see note).

In practice conventional signs are used as substitutes for a great many of the words in the above

description. Locking sheets are ruled in two columns, in the first of which the numbers of the levers are given in numerical order, and in the second, following the numbers in the first, are the numbers of the levers which they lock. Nothing is said about the levers whose numbers are given in the first column being reversed, but it is always understood that they must be reversed to accomplish the locking which is shown in the second column. Instead of writing in the word "reversed" in the second column, a circle is drawn around the number denoting a lever when that lever is locked reversed.

The locking sheet described above would in practice appear as follows:

LEVER	LOCKS		
1	2		
2	3	7	
3	4		
4			SEE NOTE
5	4	6	
6	4		SEE NOTE
7	3		SEE NOTE
8	7		

Fig. 85.

Note.—As explained in an earlier chapter, if one lever locks another lever normal, the opposite is always true, i.e., the last lever locks the first normal. In the locking sheet illustrated No. 3 locks No. 4 normal. No. 5 locks No. 6 normal; No. 2 locks No. 7 normal; therefore No. 4 locks No. 3 normal; No. 6 locks No. 5 normal; No. 7 locks No. 2 normal. It is not customary to show this duplication in drawing off locking sheets, and as illustrated, no mention is made in the locking given for the last named levers of the fact that they lock the first named normal.

This is merely a conventionality and no harm would be

done if it was shown, but as the established custom is to omit it this custom had better be followed.

Where special locking appears, the letter "w" is placed in the second column between the number of

LEVER	LOCKS		
1	5	W	7

Fig. 86.

a lever which is locked, and the number of the lever or levers which must be in an assigned position before that locking is accomplished. To illustrate:

Fig. 86 would indicate that lever No. 1 when reversed locks lever No. 5 normal, when lever No. 7 is

LEVER	LOCKS			
1	6	W	8	5

Fig. 87.

reversed, and Fig. 87 would indicate that lever No. 1 when reversed locks lever No. 6 reversed when lever No. 8 is reversed and lever No. 5 is normal.

In large machines where some levers lock a great many others, and where if the special locking was shown on the same line with the straight locking it might be confusing to distinguish the special from the straight, it is customary to show all the straight locking on one or more lines, together, and each special combination on a line by itself.

For example: Fig. 88

LEVER	LOCKS				
23	5	28	32	44	44
	11	W	27		
	36	W	29	16	

Fig. 88.

would indicate that lever No. 23 when reversed would lock lever No. 5 reversed, levers Nos. 28 and 32 normal, lever No. 44 normal and reversed, lever No. 11 normal, when lever No. 27 was reversed, lever No. 36 reversed, when lever No. 29 was normal and lever No. 16 was reversed.

The method of describing locking on locking sheets just explained is that used by many, but it is only proper to add here that one large manufacturing company draws up its locking sheets in a different form. Its method is to rule the sheets in three columns as Fig. 89.

LEVER	WHEN	LOCKS
23		5 28 32 44 44
	27	11
	16 29	36

Fig. 89.

The locking given is the same as that just described and means that lever 23 when reversed locks lever 5 reversed levers 28 and and 32 normal and lever 44 normal and reversed; that when lever 27 is reversed it (lever 23) locks lever 11 normal and that when lever 16 is reversed and lever 29 normal it (lever 23) locks lever 36 reversed.

There are some advantages in drawing off locking this way as the specials can be put in the "when" column first and act as a check to the draftsman when completing his sheet.

However, the former method is that most generally employed and will be used throughout this work.

Dog sheets are neither more nor less than plan views of the locking beds of machines with all parts omitted except the dogs, locking bars, cross locks and drivers, with Saxby and Farmer machines, and dogs, tappets and locking bars in vertical locking machines.

Dog sheets for Saxby and Farmer machines are al-

ways shown with the front of the locking bed at the top of the drawing. This gives the view of the locking bed as if the observer was standing behind the machine, and consequently No. 1 lever is at the right and all locking bars in mechanical machines move towards the *right* of the drawing. As explained earlier, in some types of power machines with Saxby and Farmer locking, some levers drive the bars both ways. Dog sheets for vertical locking beds show the tappets and dogs as they would appear to an observer standing with No. 1 lever at his left. As the direction in which the locking bars in these machines move is governed by the position of the notches in the tappets, with respect to the side of the tappet, it makes no difference whether the tappets are raised or lowered by the movement of the lever or its latch. In the case where one lever locks another reversed, the direction in which the tappets move does, of course, have some bearing, but as in that case the first lever cannot be reversed until the second has been reversed, the position of the notch in the second lever shows at a glance in which direction the tappets must move.

Fig. 90 shows a dog sheet for a Saxby and Farmer machine, and Fig. 91 one for a vertical locking machine, in which the tappets move upward, and one for a vertical locking machine, in which they move downward, each of which accomplished the locking shown in the locking sheet first described in this chapter.

There is no fixed mathematical method by which the proper locking to be shown on locking sheets or the proper distribution of the dogs on dog sheets, may be calculated.

There are a few general rules which must be observed, after which the question becomes merely a matter of skill and practice, like the playing of a game of chess or checkers. In fact, two experts

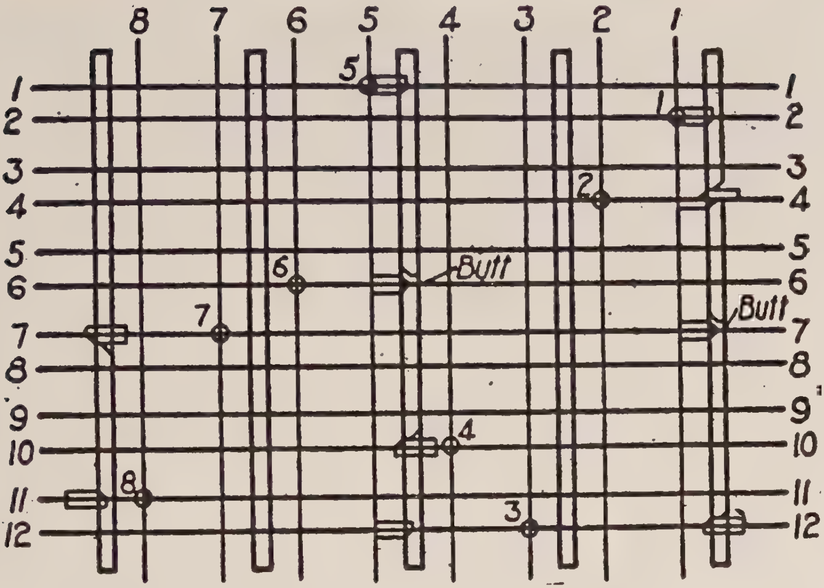


Fig. 90.

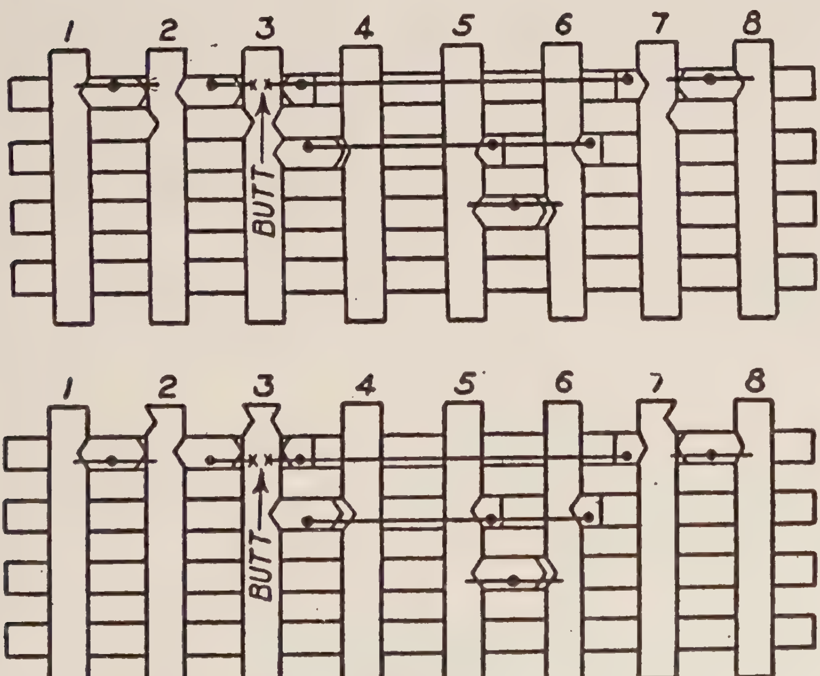


Fig. 91.

working on the same track plan, may, and frequently do, design different locking and dog sheets, either of which will accomplish the desired results. There is probably no one thing in signal engineering that requires as much mental concentration as the designing of locking. From three to five years' constant practice is considered necessary to produce a skilled locking expert.

The vast majority of the dog sheets are made up in the drafting rooms of the signal manufacturers, few signal engineers deeming it worth while to undertake their preparation in their own offices. A great many locking sheets, too, are prepared by the manufacturers from track plans, and a general description of the traffic conditions furnished by the signal engineer, although many signal engineers who do not care to prepare their own dog sheets, do prepare and furnish locking sheets.

The manufacturers always insist on having a written acceptance of the locking in each machine, from the Railroad Company purchasing it, in order to clear themselves in case routes are not properly safeguarded by the locking. Every signal man should, therefore, be prepared to check locking and dog sheets after they have been drawn up, in order to thoroughly understand the various locking combinations they effect, and so detect any errors which may have slipped by the original designer.

As a matter of practice, too, it is always a good plan to draw up locking sheets, to design changes in the locking of machines already in service in which additions or alterations are to be made, and even to prepare dog sheets for small machines. It is very doubtful, however, if it ever pays a railroad company to have its men spend much time in designing large dog sheets. In the nature of things the skilled corps of specialists kept by the manufacturers are in a bet-

ter position to prepare them, especially as they are in close touch with the factory where the locking is to be made, than a railroad company's man who cannot devote his entire time and thought to this one branch of the art.

This is more especially true as the signal companies make no extra charge for machines, the dog sheets for which they themselves have prepared.

The following general rules apply to all locking sheets:

1. Each distant signal lever should always lock its home signal lever reversed. As before explained, this insures that the home signal lever must be reversed, before the distant signal lever can be reversed, or, in other words, the distant signal cannot be cleared, unless the home signal has first been cleared.

2. Facing point lock levers should always lock the levers of the switches which the facing point locks secure normal and reversed. The reason for this is explained as follows: The plunger of a facing point lock is passed through the lock rod of the switch or derail when the facing point lock lever is reversed. Now, if, when the facing point lock lever is reversed, the lever-man is free to unlatch and move the switch lever, he will throw a shearing strain on the plunger which might break it or the lock rod. By having the switch lever locked, either normal or reversed, by the lock lever, this is prevented.

3. Where switch and lock movements are used the signal lever operating each signal that governs any route over the switch, should lock the switch and lock lever normal, if the switch is to be in its normal position when the signal is clear, or reversed, if the signal governs a route over the switch in its reversed position.

In the case of derails, as there is no route over them

in their normal position, the signal lever should lock the switch and lock lever reversed.

4. Where facing point locks are used, the lever of each signal governing a route over any switch locked by a facing point lock should lock the facing point lock lever reversed. This insures that the switch

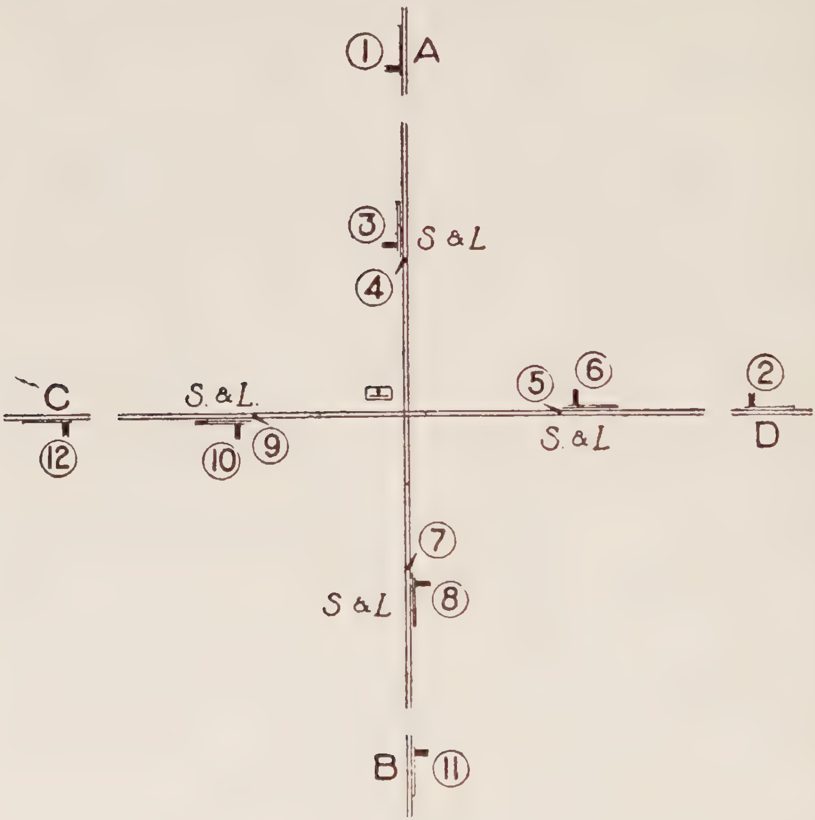


Fig. 92.

points are locked by the facing point lock plunger before the signal can be cleared. This also applies to derails.

There are three elementary components to which, like the prime factors of a number, all interlocking may be reduced.

Each interlocking plant is made up of one or more of these elements.

They are:

(1) A plain crossing.
(2) A junction.
(3) A crossover between two tracks.

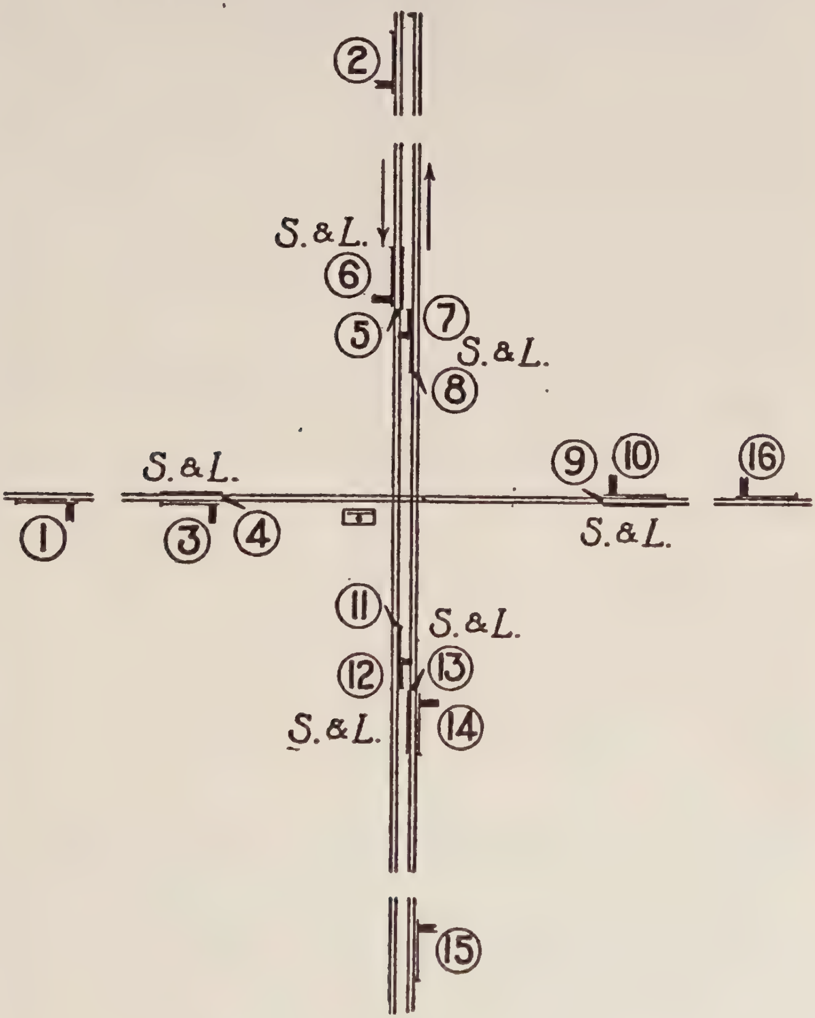


Fig. 93.

The correct signalling for a plain single track crossing is shown in Fig. 92, in which 1, 2, 11 and 12 are

the distant signals, 3, 6, 8 and 10 the home signals, and 4, 5, 7 and 9 the derails shown in the figure as operated by switch and lock movements.

Where one of the lines is a double and the other a single track line the signaling is shown in Fig. 93. This is merely an evolution from the other.

The direction of traffic on the double track line is shown by the arrows. It is, as explained in an earlier chapter, customary to signal reverse movements, i. e., those opposite to the established direction of traffic, with dwarf signals, and no distant signals are provided for these, hence signals 7 and 12 are dwarf signals.

Fig. 94.

Where both lines are double track, we have a further evolution, as shown in Fig. 94.

In order to prepare the locking for the arrange-

ment shown in Fig. 92 the reader should remember that in the plan everything is shown in its normal position; that is, the derails are open and the signals are at "caution" for the distant, and "stop" for the home. In order to let a train pass from A to B, therefore, derails 4 and 7 and home signal 3 must be reversed, and distant signal 1 if the train is approaching from beyond it should also be reversed.

Further than this: It is a cardinal principle of all interlocking, that a route given to a train must insure that train a safe passage through the interlocking limits, so far as the interlocking is concerned. Therefore, when derails 4 and 7 are reversed, derails 5 and 9 must be held normal, so that any train approaching on the other line C-D would be run off the track and prevented from running into the train which had been given the right of way. As it would be highly dangerous and only inviting disaster to give a clear signal with a derail in the route it governs normal, all signals on the line C-D must also be normal.

It is not of such vital importance that signals 8 and 11 should be held at normal because if a train was approaching from B towards A at the time a train moving from A towards B was given the route, the fact that signals 8 and 11 were at normal would not prevent a collision between the trains. It is nevertheless the general practice to arrange the locking so that when 3 is clear 8 must be normal, and vice versa.

In order then to insure the safeguards just described, derail levers 4 and 7 should each lock derail levers 5 and 9 normal. As before explained, this carries with it that 5 and 9 will lock 4 and 7 normal, so that when either derail in either line is reversed, both derails in the conflicting line must be normal.

In order that signals 6 or 10 may not be cleared while route is given from A to B, we have lever 6 locks levers 5 and 9 reversed, also lever 10 locks levers 5 and 9 reversed. As before explained, this locking prevents lever 6 or 10 from being reversed until after 5 and 9 have been reversed, and as 5 and 9 are locked normal by 4 and 7, neither 6 nor 10 can be cleared while 4 or 7 is reversed. The distant signals all lock their home signals reversed, so that only that distant signal can be cleared whose home signal is first set clear. Lever 3 should lock lever 8 normal, and lever 6 should lock lever 10 normal, to prevent the clearing of opposing signals on the same route, which, as just explained, is not vital, but is considered good practice.

The locking sheet for this machine then would read as follows:

LEVER	LOCKS		
1	3		
2	6		
3	4	7	8
4	5	9	
5			
6	5	9	10
7	5	9	
8	4	7	
9			
10	5	9	
11	8		
12	10		

Fig. 95.

It is very common practice to operate both derails in one line at a crossing by one lever, and to lock them with facing point locks thrown by another lever.

Such an arrangement is shown in Fig. 96.

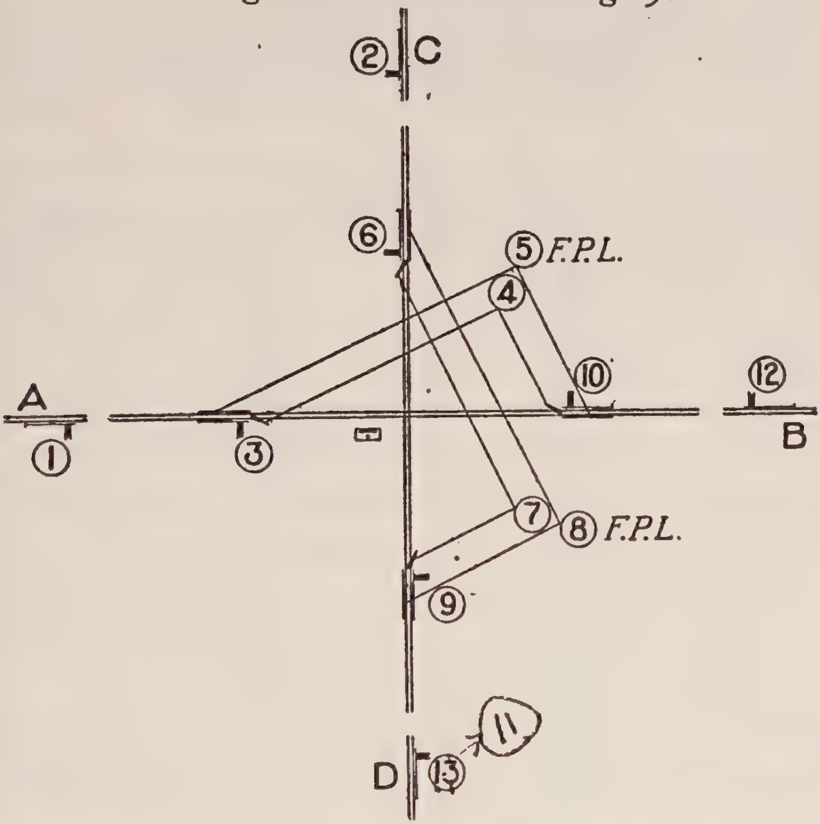


Fig. 96.

Here the locking would be as shown in Fig. 97.

In the cases of the double track line crossing the single track and of the two double track lines crossing each other, there is no essential difference. There need, of course, be no locking between the derails and signals on the parallel lines of the double track because they do not conflict in any way.

Fig. 98 shows a junction interlocked and the locking sheet therefor.

Here it should be noted that 4 does not lock 5 normal, directly. No. 5 locks 8 normal, however, and as 4 locks 8 reversed 4 cannot be reversed until 8 has been reversed, which locks 5 normal.

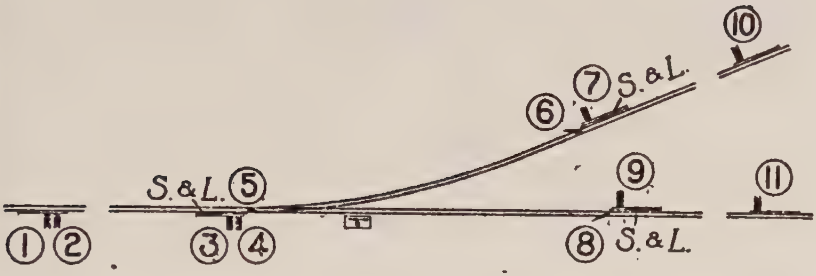
If facing point locks were used it would be good practice to operate derail shown as No. 6 and

LEVER	LOCKS	
1	3	
2	6	
3	5	10
4	7	
5	4	
6	8	9
7		
8	7	
9	8	
10	5	
11	9	
12	10	

Fig. 97.

switch No. 5 by one lever and lock them by another. It would never be desirable to reverse No. 6 without No. 5, so that no complication could arise from working them both together.

Fig. 99 shows such an arrangement in which lever No. 5 throws the switch and derail and lever No. 6 throws both locks and bars. No. 8 is still left a switch and lock movement. If it, too, is to be



LEVER	LOCKS
1	3
2	4
3	6 5 7
4	8 5 9
5	6
6	5
7	6
8	5
9	8
10	7
11	9

Fig. 98.

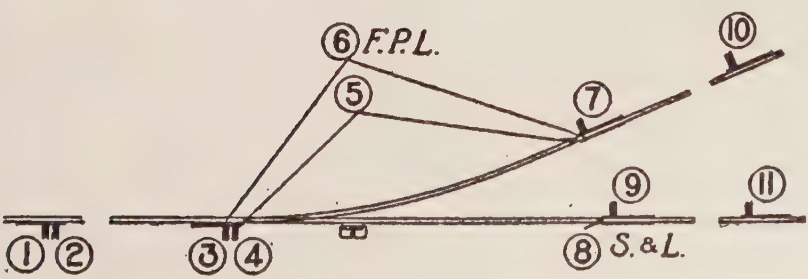


Fig. 99.

LEVER	LOCKS		
1	3		
2	4		
3	5	6	7
4	6	8	9
5	8		
6	5	5	
7	5	6	
8			
9	8	6	
10	7		
11	9		

Fig. 100.

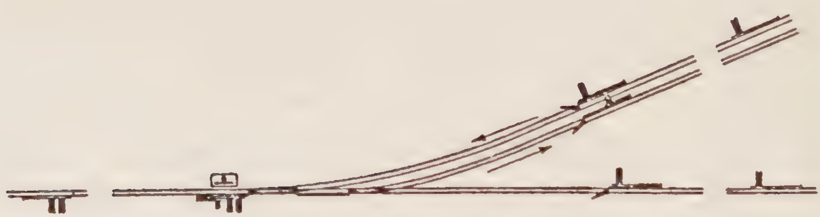


Fig. 101.

equipped with a facing point lock an additional lever will have to be added for the lock.

The locking sheet for Fig. 99 is shown in Fig. 100.

The only other case of a junction which can come up without introducing either a crossing or a cross-over, is that in which a double track line joins a single track line, and is shown in Fig. 101.

The direction of traffic on the double track line is indicated by the arrows. There is so little differ-

ence between this and the single line junction that I shall not take space here to give the locking. The reader no doubt can by this time make a locking sheet for this figure himself.

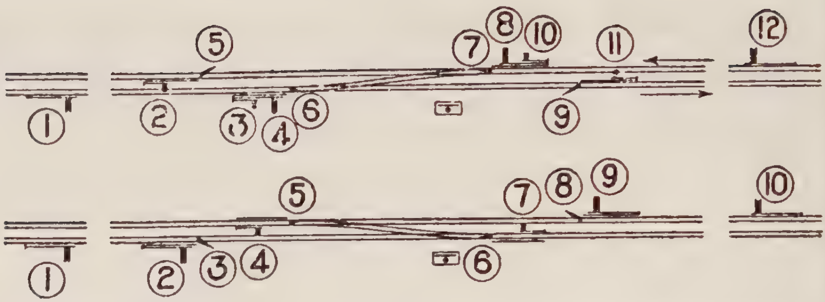
Crossovers may be either facing point or trailing point. There is a slight difference in the signaling for a trailing point from that for a facing point.

Fig. 103 shows one of each, with its proper signaling. A crossover is very nearly akin to a junction, but the reader will no doubt notice the difference in the arrangement of derails; one end of the crossover itself takes the place of one of the derails at a junction, but another derail has to be added to protect anything using the crossover from a false move which could not be made at a junction.

LEVER	LOCKS	
1	4	
2	5	8
3	7	10
4	9	11
5	6	
6		
7	6	
8	5	
9	6	
10	7	
11	9	
12	8	

Fig. 102.

The locking sheet for the facing point crossover would be as shown in Fig. 102.



LEVER	LOCKS		
1	2		
2	3	7	
3	5	6	
4	5	5	
	8	W	5
	9	W	5
	6	W	5
	7	W	5
5			
6			
7	6	6	
	3	W	6
	5	W	6
8	5	6	
9	8		
10	9		

Fig. 103.

For the trailing point it is shown in Fig. 103.

Fig. 104 illustrates an interlocking plant in which are combined all three of the primary elements already referred to.

Here when either route on the line A-B is "set up" (the difference in the routes being only in the use of the signals) both derails on the line C-D, both derails on the line E-F and the derail on the line G-H must be locked normal. The position of the crossovers 11 and 18 is, of course, immaterial so long as derails 8, 10, 20, 22 and 24 are normal, so that it is unnecessary to have any locking between them and the derails on line A-B.

The locking sheet for this arrangement is shown on pages 232 and 233.

There are one or two peculiar points about this locking on which I shall comment.

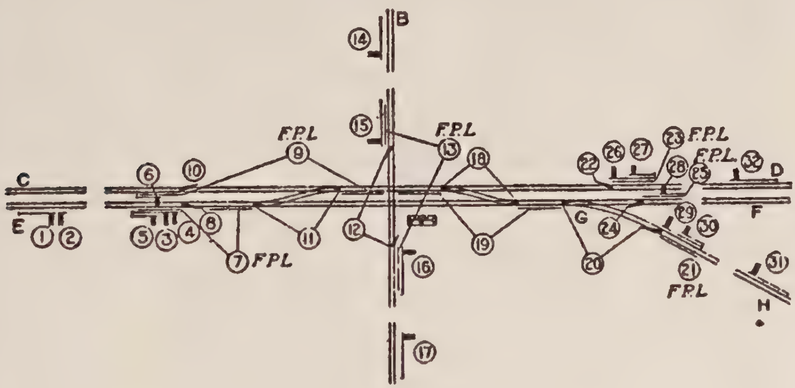


Fig. 104.

In the first place it will be noted that signal 5 gives a route through crossover 11, reversed, and back through crossover 18, reversed, to either F or H.

This requires quite a bit of special locking and in actual practice is rarely done, as the distance between crossovers 11 and 18 is so short that it is assumed that this loop around movement would never be made unless the track on the line E-F between the crossovers was torn up or otherwise obstructed, in which case trains could be looped around by verbal orders or hand signals given by the leverman.

LEVER	LOCKS				
1	3				
2	4				
3	7	11	19	21	30
4	7	11	19	25	28
5	7	9	11	19	
	23	W	18		
	27	W	18		
	25	W	18	20	
	28	W	18	20	
	21	W	18	20	
	29	W	18	20	
6	9	10	19		
	23	W	18		
	26	W	18		
	25	W	18	20	
	28	W	18	20	
	21	W	18	20	
	29	W	18	20	
7	8	11	11		
8	12				
	18	W	11		
9	10	10	11	11	
10	11	12			
11					

Fig. 105.

LEVER	LOCKS				
12	20	22	24		
13	12				
14	15				
15	13	16			
16	13				
17	16				
18					
19	18	18	20	20	
20	24				
21	20				
22	18				
23	22				
24	11	W	18		
25	24				
26	9	10	19	23	
27	7	9	11	19	23
28	25	19			
	9	W	18		
	10	W	18		
	7	W	18		
	7	W	11	18	
29	9	10	18	19	21
30	11	7	19	21	
31	29				
32	26				

Fig. 106.

Derail lever 10 is locked by its lock lever 9, both normal, and reversed. This is because the same lever throws the lock for crossover 11. Now if lever 9 locked lever 10 reversed only, 10, as already shown, would have to be reversed before 9 could be moved, but in case of a route through No. 11 reversed, 10 would be locked normal, therefore 9 could not be thrown to lock 11.

For this reason signal No. 6 must lock derail 10, reversed, directly, and not through the medium of lock lever 9, as is the case with the other derails.

Here too in actual practice both ends of No. 11 woud probably be locked by one lever, as with 18, and 8 and 10 would either be operated by switch and lock movements or an additional lock lever would be provided for one of them. The arrangement shown in the figure is intended for illustrative purposes.

A detector bar, fifty or fifty-three feet long, is a heavier load on a lever than a switch, and where two bars are put on one lever with 800 to 900 feet of pipe, it requires about all the strength of an ordinary man to throw them. There is quite a general tendency today to use a separate lever for each bar wherever possible.

As a general rule a beginner in designing locking sheets should imagine himself in the place of the leverman, and see what levers must be reversed to set up each route and then see what levers *must be normal* to guarantee a safe passage to a train over each given route. From this a preliminary locking sheet can be made.

Mr. A. M. Wellington, in his Economic Theory of Railroad Location, says that a locating engineer after having picked out what he thinks is the best line, will generally, if he looks at it a second time, find where he can improve on his first selection. This is certainly true of designers of locking sheets. It is

generally the custom to have two men draw up locking sheets from the same track plan, independently of each other, and then compare notes. What one misses the other one is likely to include. Where only one man can work on it he should draw up one sheet, commencing with lever No. 1, then, without referring to the first sheet, draw up another, commencing with the highest numbered lever and working backwards. After that is finished compare the two, lever by lever, and most errors in each will be caught. It is no easy thing to learn, and requires a vast amount of practice to become a proficient at it.

In the foregoing figures no special attention has been given to systematic numbering of the levers, and no allowance has been made for spare spaces which are generally left in each machine to provide for any additions which may be made thereto later on.

The numbering of the levers in a mechanical machine depends somewhat on the type of leadout used. Levers for wire connected signals are generally placed together at the ends of the machine, so that the box chain wheels which carry the wires away from the tower may be placed at either end of the leadout platform, and the wires thus turned and led away without crossing the pipe lines. In running the pipe lines alongside of a track it is good practice to have the pipe which operates the function nearest the tower on the inside of the pipe run—that is nearest the track. In this way when it turns and goes off to its function it will not have to cross under any other pipes. Such an arrangement as this prevents the chance that in case of a cross pipe's being caught by something dragging from a car and being torn up, it will also tear up the other pipes under which it crosses.

This is called "dropping off" on the inside of the pipe run.

With a rocker shaft leadout almost any system of

numbering the pipe connected levers may be followed, and the pipes so arranged as to drop off inside.

With a crank or deflecting bar leadout, however, this is not so easily done, and it will be found most often convenient to draw up a leadout plan in pencil and number the levers according to the way their pipes drop off.

This method will generally scatter switch lock and signal levers indiscriminately through the machine, but it also as a rule groups the levers in each combination together so that the leverman does not have to move so far in setting up any particular route.

Some signal engineers prefer to group all the distant signal levers together at the ends of the machine, then the home signal levers, and have all lock and switch levers in the center. With a crank or deflecting bar leadout such an arrangement often requires a good many extra cranks on the ground, and although it does well enough with small machines, with large ones it makes the operation much less convenient.

With power machines the levers in each combination are generally grouped together and numbered accordingly.

There is no absolute rule for the allowance of spare spaces to be made. To leave twenty-five per cent of the spaces spare is not a bad rule for power machines, and with mechanical ones it is largely a matter of judgment. If a plant is being put in at a plain single track crossing where there is a likelihood of double tracking, it is not a bad idea to draw up a preliminary double track plan with facing and trailing point crossovers and passing track switches, and get a machine large enough for such a combination, with all unnecessary levers left out—spare spaces.

It is a good rule to look the ground over carefully before making up a leadout plan, as it is some-

times necessary to cross tracks in a way which would not be apparent from the track plan, and this may have an effect on the numbering, and perhaps simplify it.

The preparation of dog charts is much more a matter of practice and skill, even, than is that of locking sheets.

The object to be attained is to arrange the dogs in such a way that as few of them will be required as possible, thus saving material and labor in the construction of the machine. It is quite possible to have perfectly safe locking and to accomplish everything called for in the locking sheet by many different arrangement of dogs. Most generally one will be found, however, more simple than the rest, which to the expert designer would be the correct method to employ.

A very thorough knowledge of shop practice in manufacturing locking is a necessary part of a good designer's education.

With Saxby and Farmer machines it is the general rule first to study the locking sheet to find out what levers lock the same lever in a certain position, and also what special locking is to be provided for. The latter is generally laid out first so as not to have a "when" dog on a locking bar adjacent to the locking bar carrying a dog which drives through the when. After that the simple locking is worked out from No. 1 locking bar outward. An effort should be made to get all the locking on as few bars as possible. This may often permit of the use of a narrower locking bed than the number of levers in the machine would require if each lever had a locking bar to itself, thus saving space in the tower and possibly permitting the use of a larger machine.

This is something the manufacturers will not do unless their attention is called to it when the machine

is ordered, as the rule is to ship out machines with their full complement of locking bars whether all the bars carry dogs or not.

In vertical locking the tappets take the place of the cross locks of the Saxby and Farmer type, and the operation may be said to be reversed in that the levers drive the crosslocks (tappets) which in turn drive the bars and dogs, while in the Saxby and Farmer the levers drive the locking bars and dogs, which in turn drive the crosslocks.

To a person who thoroughly grasps this distinction, there is no vital difference in the method of designing vertical locking from that employed in designing that for Saxby and Farmer machines.

The special swing dogs with the vertical type are attached to the tappets and not to the locking bars. In each locking space with a vertical locking bed eight locking bars, five front and three back, may travel. This makes it easy to assemble a great deal of locking in a very small vertical space. This unfortunately is of no great advantage as the width of the tower has to remain the same anyway.

When an interlocking machine is shipped out from the factory, it is taken apart and boxed. As it has been put together and tested, such of the pieces as require it are marked with figures and letters stamped on them to show how they are to be put together.

With a Saxby and Farmer machine the crosslocks are all stamped with a number and the letter B, as "3 B." This means that that crosslock belongs in bracket No. 3. On each end another number is stamped, as 2, 6. This means that the end stamped 2 is next to locking bar No. 2, and the end stamped 6 is next to the locking bar of that number. This shows at once the exact position in the locking bed of this particular piece of crosslock. The locking bars are numbered as already described. The dogs

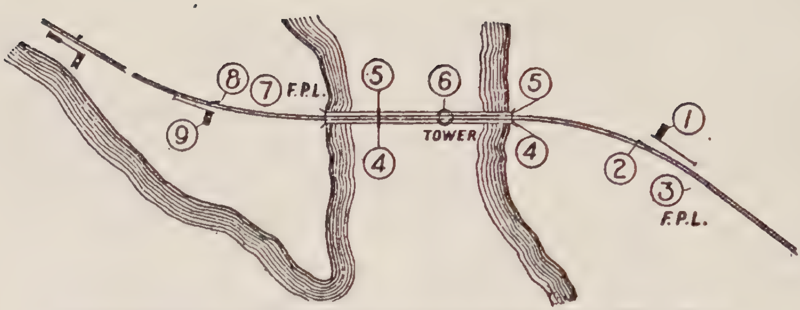
are left rivetted to them so there is no necessity to number them. The drivers are also left rivetted to the bars, but as a locking bar may be cut and driven by two or more levers, each driver has the number of its lever stamped on it.

With vertical locking the locking bars are shipped out with the dogs rivetted to them. The bars are lettered T. M. and B., standing for top, middle and bottom. With the front locking there are two tops and two bottoms. The drilling by which the screws holding the dogs to the bars is made in the dogs, shows which is the upper and which the lower top or bottom. The shape of the dogs shows which is the front and which the back locking.

Other parts of the machine are numbered so that there is no difficulty in assembling it.

There is another point which is a factor in some interlocking plants, but not in all, which should be called to the student's attention. This is the locking of drawbridges.

It is the general custom now-a-days to have one lever in the interlocking machine lock the engine by which the movable part of the bridge is put in motion, so that it, the engine, cannot be started when this lever is reversed. This can be done by using an ordinary bolt lock or facing point lock connected to the lever of the engine, and also to that of the machine. By having all other levers in the machine either directly or indirectly lock this first lever reversed, no lever in the machine can be reversed until the engine is cut out, and the engine cannot be cut in until everything is normal again. Another lever in all drawbridge machines is devoted to hooking and unhooking the bridge couplers. The whole combination had best lock this lever reversed, also, so as to insure that the pipe lines or wires, if a power plant, are



LEVER	LOCKS		
1	3	7	9
2	5		
3	2		
4	6		
5	4		
6			
7	8		
8	5		
9	7	3	
Nº 4 OPERATES BRIDGE LOCK			
Nº 5 " " COUPLER			
Nº 6 LOCKS ENGINE			

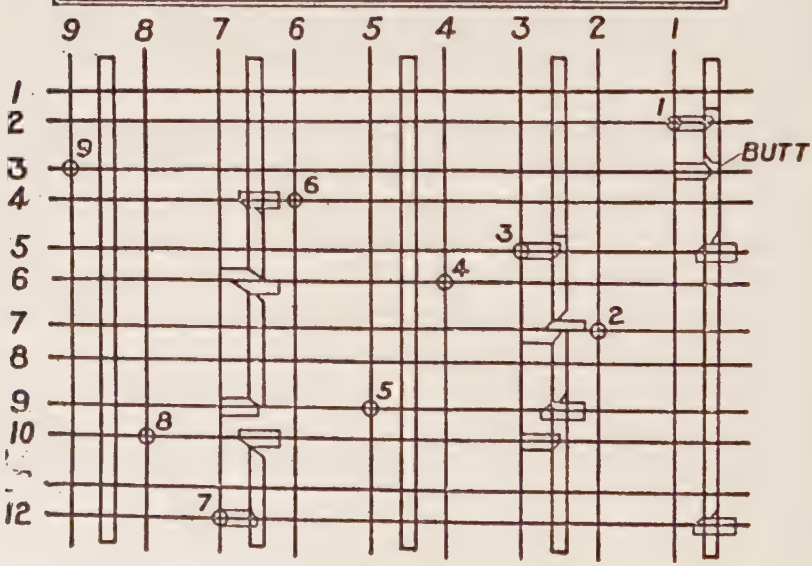


Fig. 107.

coupled together at the coupler before any of them are moved, or current applied.

The lifting or spreading rails at the end of the bridge are treated as switches, but are locked with facing point locks of a much heavier construction than those used for switches.

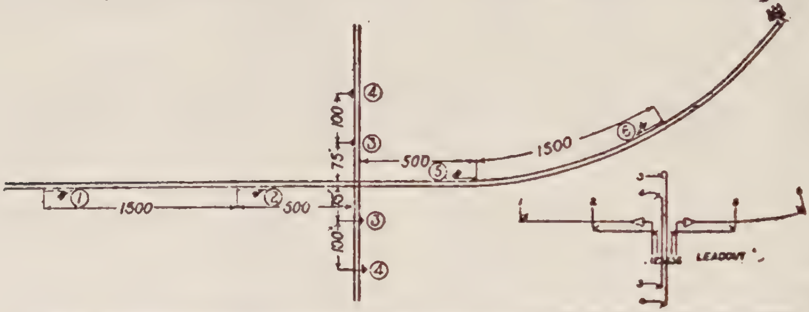
Fig. 107 shows a track plan locking and dog sheet for a single track drawbridge taken from actual practice, which will serve to illustrate what has preceded on this head.

Sometimes where very unimportant lines cross lines of heavier traffic, and it is considered necessary to protect the crossing with interlocking, the expense of permanent levermen is avoided by putting the interlocking machine in a building which can easily be entered by trainmen of the inferior line. Trains on this line are stopped at the home signal and one of the trainmen goes ahead and acts temporarily as leverman, until the train has pulled over the crossing far enough for its rear end to clear the farther derail, when it stops and the trainman restores the routes to their normal position, after which he boards the train and it proceeds.

In such cases, I will say in passing, that the signals and derails on the superior line stand normally reversed, so that trains on that route always find the signal clear unless the crossing is actually in use by a train on the other line.

To prevent the possibility that an inexperienced or careless trainman might leave the route set up for the inferior line, which would mean leaving the signals at caution, and stop, and the derails open on the superior line, and would cause trains on that line to stop unnecessarily, one of the levers in the interlocking machine which is locked reversed, either directly or indirectly by the entire combination in addition to some other function which it may perform,

also locks the door of the cabin (such machines are usually arranged for horizontal leadout, and are placed in a one-story building which is called a cabin in contradistinction to the name tower applied to a two-story building), until all routes are returned to



LEVER	LOCKS				
1	2				
2	3				
3					
4	1	2	3	5	6
5	3				
6	5				
LEVERS 1, 2, 4, 5, 6 ARE KEPT IN THE REVERSE POSITION AND ARE ONLY SET NORMAL WHILE ELECTRIC CAR IS USING THE CROSSING.					

Fig. 108.

their normal condition, thus holding the temporary leverman a prisoner in the cabin until he has placed all signals and derails as they should be. Something similar to a facing point lock is generally used for the door lock.

At crossings of steam railroads and electric inter-

urban lines this condition comes up frequently, and the same results may be obtained by using double derails, as with a door lock.

Fig. 108 illustrates such an arrangement, giving also the locking sheet. In this particular case no derails are placed in the track of the steam railroad. The plan is taken from actual practice and no derails were deemed necessary under the conditions which existed.

The only reason that such a plan will not answer with an inferior steam road, is that the outside derails would have to be placed a full train length from the inside ones, which would make them too far away to be operated with safety by a pipe line. The door lock does just as well and is cheaper than a long pipe line would be.

Besides the locking sheet and dog sheet, what is known as a *manipulation chart* should be drawn up for each interlocking plant.

This manipulation chart is a track plan, not usually drawn to scale and generally very much larger than the regular track plan. On this all the lever numbers are shown at their respective functions in large block figures, so that they may be read from some little distance. Block letters are used to distinguish the different routes. Beneath or alongside of the track plan each route is shown, as A to B, C to D, E to F, etc., etc., and after the route the numbers of the levers which must be reversed in order to "set up" that route. These numbers are given in the sequence in which the levers are to be reversed.

These manipulation charts are always drawn with the top of the plan representing the side of the track farthest away from the leverman as he stands facing the machine, so that he has the track plan before him, just as it would look if he looked down at the ground from a window behind the machine.

Either a blue or white print copy of the manipulation chart should be framed neatly and hung up in the tower behind the machine, so that the leverman will

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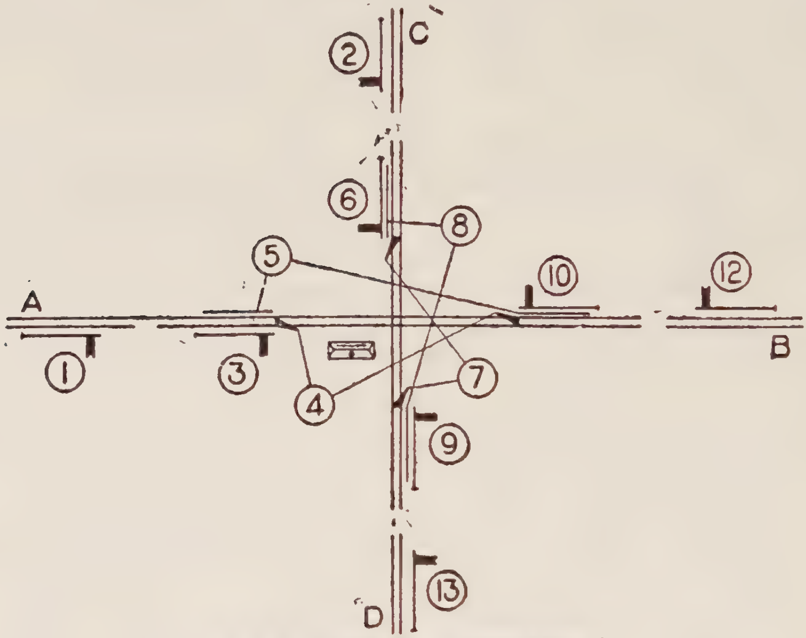


MANIPULATION

FROM	TO	REVERSE	LEVERS.		
A	B	4	5	3	1
C	D	7	8	6	2
B	A	4	5	10	12
D	C	7	8	9	13

Fig. 109.

always have it in front of him to refer to as an aid in handling the levers. As one print of this plan very likely may, and frequently does last a number of

years, it pays to spend a little time on it, and color the signals and tracks so as to make them more conspicuous and give the whole drawing a finished look, which adds very much to the general appearance of the operating room of the tower.

Black block letters and figures of various sizes are to be had which are gummed on the back like a postage stamp, and a great deal of draftsman's time may be saved, and a very neatly lettered print secured, by using such figures and letters on the tracing. By using a straight edge and being careful just as good results may be had as with the laborious hand lettering which some draftsmen put in on these tracings.

Levermen generally become so familiar with their machines in a few days that they rarely have to refer to the manipulation chart even at large plants, but new men cannot be expected to handle a machine promptly unless one is before them, and as men may change at any time a correct manipulation chart should be in all towers at all times.

Fig. 109 gives a typical manipulation chart for the interlocking shown.

As an additional aid to the levermen the levers, or at least that part of them which appears above the floor, except the handles, which are polished, are painted various colors to correspond with the function which they perform.

For instance, where distant signal blades are painted green, and home signal blades red, the distant signal levers are painted green, home signal levers red, switch levers black, lock levers blue, switch and lock levers half black and half blue.

Before putting a plant in service, the locking of the machine should be thoroughly checked. The best way to do this is first to go carefully over it with the dog sheet, bar by bar, dog by dog, and tappet by tappet. Then by reversing all the levers in the

machine for each given route and testing all the other levers it can soon be seen if anything is left unlocked which should be locked.

If any changes ever have to be made in the locking of a machine once in service, they should be first drawn in colors on a copy of the dog sheet and thoroughly checked, after which the plan should be given to a reliable mechanic to make the change. A dog misplaced in a machine may leave a dangerous flaw in the locking combination which may escape detection for years, and too much pains cannot be taken to insure that changes are properly made.

CHAPTER XVII.

POWER DISTANT SIGNALS—CROSSING BARS—TIME LOCKS—ELECTRIC LOCKING—SWITCH PROTECTION SIGNALS.

In an earlier chapter attention was called to the fact that distant signals at mechanical interlocking plants were not always operated by pipe or wire lines.

In fact, it has become very general practice to use what are known as *power distant signals.*

As a general thing such signals are operated by electric motors, current to run which is supplied by a local battery of Lalande cells. The motors used for such signals are constructetd to operate on ten volts pressure.

At one time signals, the motive power for which was carbonic acid gas under very great pressure, were used to some extent for this purpose, but motor signals have been so much improved of late years that at present they virtually monopolize the field.

With the gas signals, gas was admitted to a cylinder which operated the signal blade by a valve controlled by an electro magnet much as is done with electro pneumatic interlocking signals.

Where power distant signals of any type are used, they are either operated by a separate lever in the machine, just as if they were mechanical signals, or less frequently by the same lever which operates the home signal.

The former practice is preferable, because it allows

independent use of the distant signal, although with the other an arrangement may easily be made by which a train on passing the distant signal will automatically set it at caution before the home signal is set at stop by the leverman.

Where separate levers are used, the locking in the machine is the same as with mechanical signals, i. e., the distant signal lever locks the home signal lever reversed.

The general arrangement is to equip the distant signal lever in the tower with a mechanical circuit controller. Three wires are run from the tower to the distant signal, two of these are attached to the coils of a relay at the signal, the other is attached to a mechanical circuit controller connected to the arm plate of the distant signal. A short connection is made between the other side of this circuit controller and one of the other wires through the local battery as will be more fully explained presently. This latter wire, therefore, acts as a common, and is so designated.

At the tower the common is connected to the negative side of a local battery there and the other wire leading to the relay, known as the control wire, is broken through the circuit controller attached to the lever, and then connected to the positive pole of the battery. When the distant signal lever is reversed, circuit is closed through its circuit controller, and current flows through the magnet coils of the relay, causing it to "pick up."

The circuit of the local battery at the signal is carried through the motor, and from there to the front contact of the relay. When the relay is picked up, therefore, circuit is closed through the motor, it revolves and brings the signal blade to clear. When the leverman returns the lever to normal, circuit through the relay is broken by the circuit controller attached to the lever. The relay drops and breaks the

local circuit, which releases the signal blade and allows it to return to normal by gravity.

The third wire leading from the tower to the signal is called the *lock wire.* Its tower end is attached to an electro magnet fastened to the frame of the interlocking machine. The armature of this magnet is fastened to a latch or hook arranged to engage a notch in a piece of steel attached to the home signal lever in such a way that the home signal lever cannot be moved, or in some cases its latch cannot be put down, when this magnet is de-energised. This arrangement is known as an *electric lock.* They are made in a number of varieties, by different makers, and to fit different machines.

At the signal end, the lock wire, as before stated, is broken through a circuit controller attached to the arm plate of the signal. From this circuit controller connection is made to the local signal battery, and from there to common. While the distant signal blade is at clear the lock circuit is broken, so that in case the signal blade should fail to return to normal when the leverman so placed the distant signal lever, the home signal lever would either be locked reversed or its latch would be locked up so that although the lever might be returned to normal it could not be latched there, and the preliminary locking would hold all conflicting levers in the machine locked, so that the route could not be changed and the leverman would be warned that the distant signal had not returned to normal. This arrangement is known as *back locking.*

Where the home signal lever also operates the distant signal, the circuit controller in the tower is attached to it. The back locking arrangement is virtually the same. The electric locks are so arranged that when the latch is down they break the circuit in that way, preventing an unnecessary drain on the signal battery.

Fig. 110 shows typical circuits for both arrangements.

There has been some discussion amongst signal engineers lately as to whether this back locking might not be dispensed with on the ground that these signals rarely if ever fail to return to normal, but up to the present it cannot be said to be good practice to give it up.

So far we have considered interlocking only in its most simple form. We have taken it for granted that the leverman, having once set up a route for an approaching train, would not take it away again and

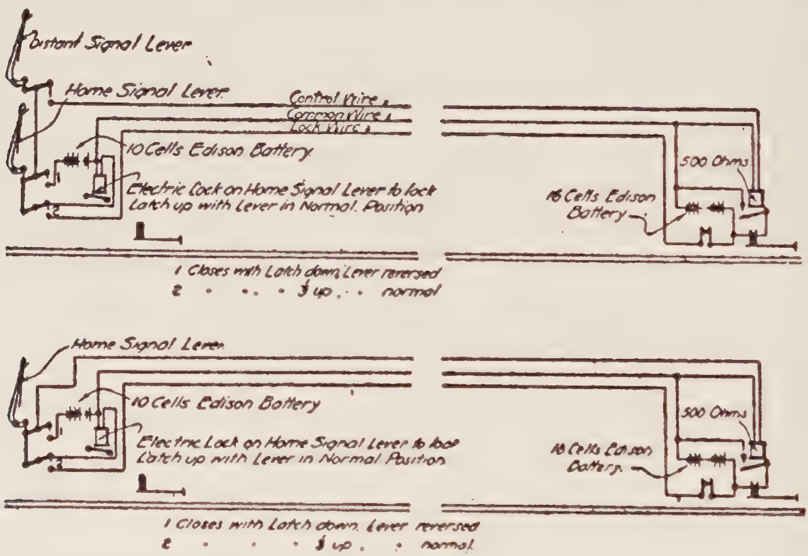


Fig. 110.

open the derails in the very face of that train as it approached, and after it had come so close to the derail that there would be no possibility of its being stopped before it had run off the track, or that with a short train or single car or engine standing on a crossing between the derails, he would not set up the opposing route for an approaching train, and thus invite a collision right on the crossing itself.

Unfortunately, levermen, like the rest of us, are not infallible and do sometimes make mistakes.

The second of the possibilities mentioned above, viz: a collision on the crossing, is often guarded against by using what are known as *crossing bars.* These are neither more nor less than detector bars placed close to the crossing frogs so that any car or engine standing on the crossing must have at least one wheel on the bar or bars. These bars are operated

Fig. 111.

by a lever in the machine. This lever usually locks the derails, in the line on which the bars it operates are placed, reversed, and is in turn locked reversed by the home signals. In this way the crossing bars must be reversed before a route can be set up and must be returned to normal before that route can be changed.

If, therefore, a wheel is standing on the bar, the route cannot be changed and the derails in the opposing route must remain normal.

The foregoing applies more particularly to cases

where there are separate crossing bars for each route. With crossings of an angle approaching ninety degrees, the bars have to be made fifty feet long, one on each side of the crossing on each route, as shown in Fig. 111. This is necessary because a truck might stand on the crossing itself and unless there was a bar on either side the other truck might not stand on one. With crossings of a sharp angle, 25-foot bars may be used and four of them put on one lever, as shown in Fig. 111, also. Here it is easily seen that a truck standing on the crossing will hold down the bar.

In such cases it is generally the custom to have the crossing bar lever lock all the derail levers normal and reversed, and then to have each of the home signal levers lock the crossing bar lever reversed. In this way no signal can be cleared until the crossing bar lever has been reversed, but when reversed the crossing bar lever locks all derail levers in whichever position they may be in at the time. Therefore, the crossing bar lever must be returned to normal before a route can be changed, which, if anything is standing on the bar, cannot be done. Another locking arrangement which accomplishes the same result is to have one derail lever lock the crossing bar lever normal and the other derail lever lock it reversed. As the derail levers lock each other normal, a route cannot then be changed without moving the crossing bars, which is the object sought. Although with this arrangement one derail lever may be set normal without first moving the bar, the other derail lever cannot be reversed until the bar has been thrown.

Crossing bars do not, however, in any way, prevent a leverman from changing routes as fast as he is able to throw the levers if nothing is standing on the crossing bars, and some very serious derailments have been caused by levermen after giving a train a route, suddenly becoming rattled and throwing the levers back to

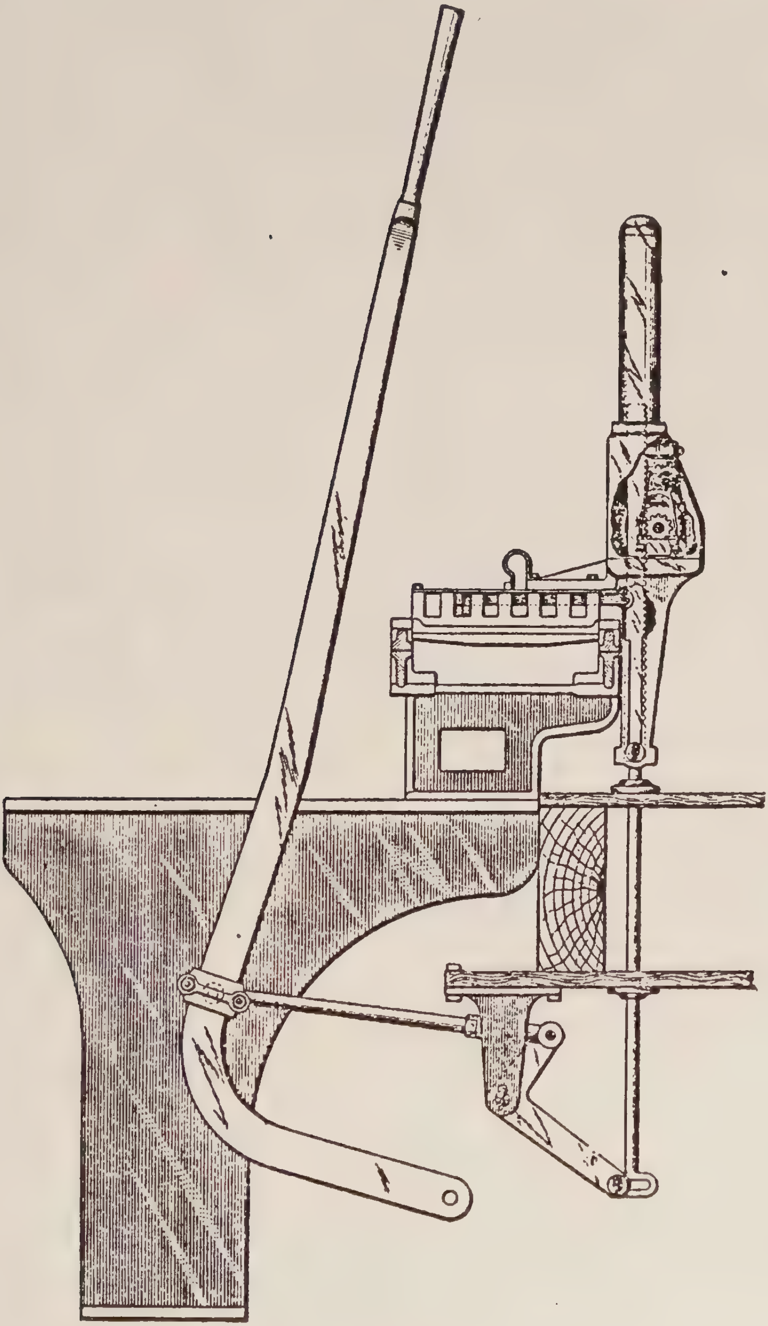


Fig. 112.

their normal positions, thus opening the derail in the very face of the train.

To prevent this the so-called time lock has been devised. One of these devices applied to a Saxby and Farmer machine is shown in Fig. 112.

It consists of a quite heavy rack placed vertically in an iron case, in which it may move up and down. This rack acts on a double pendulum much as the weight of a clock acts on its pendulum. Every time the pendulum swings it releases the rack one tooth. The rack may be arranged so that after being shoved up as far as it will go it will take from a minute to a minute and a half to "run down," after being released. This rack has a notch in its front side near the top which notch engages a roller pinned in the end of a piece of cross lock laid in a bracket in the locking bed. When the notch in the rack is opposite this roller in the cross lock, it, the cross lock, is loose, but as soon as the notch is moved past the roller the un-notched part of the rack pushes the cross lock toward the front of the machine and holds it fast there.

The rack is not connected directly to the lever, but simply rests on the end of the shaft which is moved up and down as the lever is alternately reversed and set normal. When the lever is reversed, the rack is pushed up and is held up as long as the lever remains in its reversed position. As the notch in the rack is so placed that the crosslock is free only when the rack is down, the locking is maintained during the time the rack is up. Now when the leverman returns the lever to normal he removes the support from the lower end of the rack. It commences to fall by gravity, starting the pendulum which checks its fall at every notch, thereby retarding its downward progress enough to take up a minute or a minute and a half's time before the rack reaches the end of its fall, and brings the

notch in its side opposite the roller in the end of the crosslock, thereby releasing the locking.

Fig. 113 shows the method of applying a time lock to a vertical locking machine, and Fig. 114 a method by which one time lock may be arranged so that several levers will operate it. The crank arms a a a by which the levers are attached to the small rocking

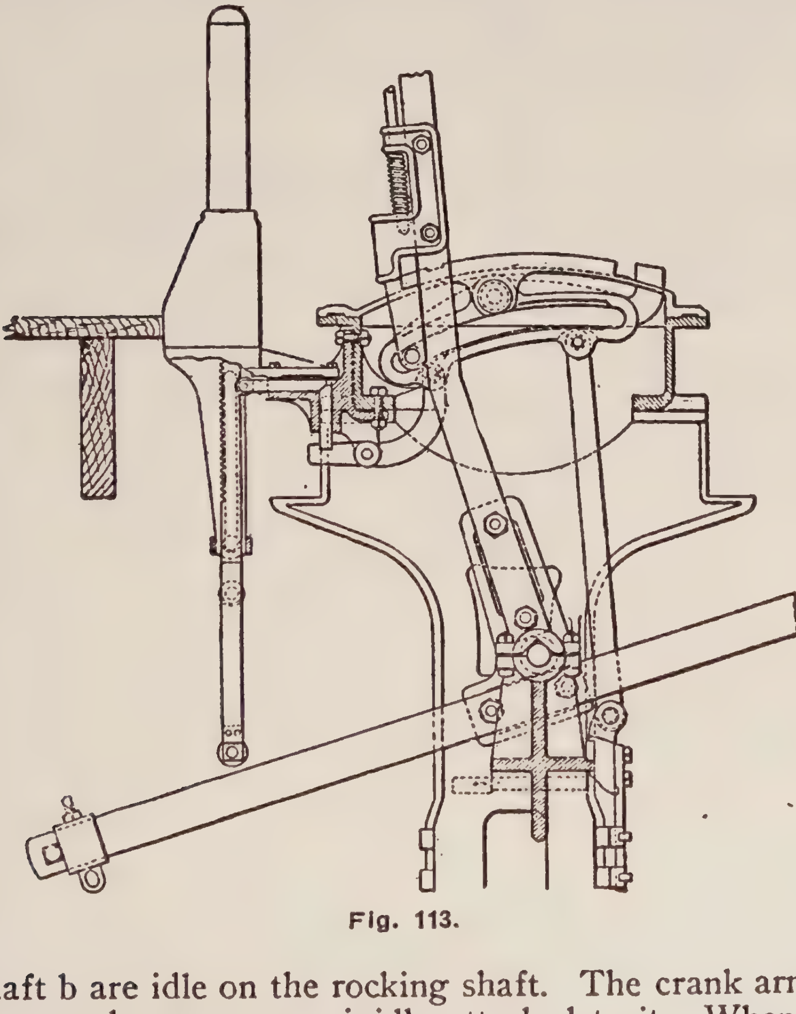


Fig. 113.

shaft b are idle on the rocking shaft. The crank arms c c c c, however, are rigidly attached to it. When a lever is reversed its crank arm a engages the crank arm c next to it and revolves the rocking shaft, shov-

ing up the rack of the time lock. If any other of the levers is reversed afterwards its crank a simply turns loosely on the rocking shaft. If, however, the first lever is returned to its normal position, the second one still holds the time lock up.

It is usual to have the time lock operated by the

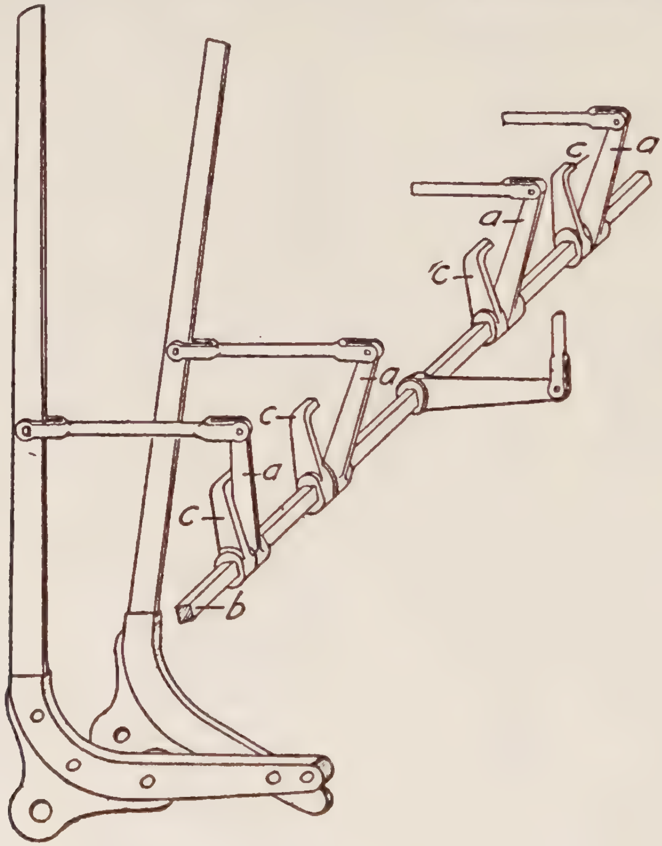


Fig. 114.

home signal levers and to have the cross lock which the time lock drives lock all the derail levers normal, and reversed. In this way a home signal can be set at normal at any time, but the derails cannot be changed until the time lock has run down.

Although there is little doubt that the use of time locks, which prevents a leverman's making a mistake

through over-haste or from excitement, virutally eliminates the chance of any mistakes being made, there are nevertheless those who are not satisfied with this, and electricity has been brought into play to insure yet greater security theoretically than is given by time locking.

This is done by what is known as electric route locking. An explanation of the *modus operandi* of electric route locking requires a prior explanation of the track circuit.

It is by the use of the track circuit that all automatic signaling is accomplished, as well as route locking, the ringing of highway alarm bells and in many cases the operation of annunciators. I shall, therefore, go into the subject fully here and explain its application to other purposes as we come to them.

In the first place, any piece of railroad track which is to be signaled automatically or used for electric route locking, is divided into *sections* by placing insulated joints in the rails as shown at "a" in Fig. 115. These insulated joints are made by inserting a thickness or two of vulcanized fibre cut into the shape of the rail section and called the "end post" between the ends of the rails; a plate of fibre or wood is laid between the angle bars and the rails and the bolts are encased in fibre bushings so that no metal touches one rail which in turn touches other metal which touches the other rail. No electrical connection, therefore, exists between the two rails. The rails between the ends of the section are bonded together with No. 8 galvanized wire extending around the angle bar and plugged into the web of the rails with pins of crescent shaped section called channel pins. Two bond wires are usually used at each joint so that if one breaks the other one keeps the connection. This bonding is necessary to insure the current's having a path of low resistance, as the scale on rails and angle bars is not always a good electrical conductor.

The sections are made from 2,500 feet to 5,000 feet long, according to conditions, or shorter for electric route locking. Good broken stone ballast will stand longer sections than clayey gravel or cinders. The only advantage in long sections is to economize on the use of material, as will be shown later.

At one end of each section is a battery consisting of

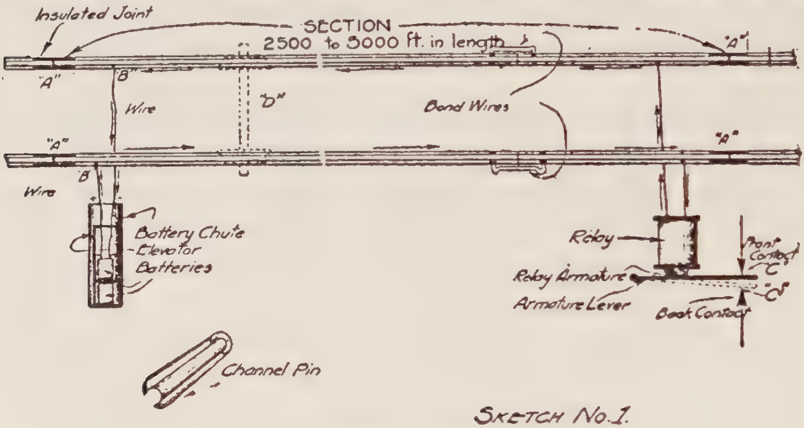


Fig. 115.

two or three cells of gravity battery. These cells are placed one above the other in a circular iron box called a *battery chute* about 7 feet long and sunk into the ground, so as to get below frost in winter. A wooden elevator is fitted inside this chute so that the battery can be drawn up and examined at any time without disturbing it. This battery is generally connected in multiple in order to reduce its internal resistance.

One pole of this battery is connected to one rail of the section and the other pole to the opposite rail as at B B, Fig. 115.

So far the circuit through the battery is open, as there is no connection between the two rails at the other end of the section. In order to complete the circuit, therefore, a relay is attached to the rails there—one side of its coils to one rail and the other side to the other rail. This completes the circuit

and the current flows from the battery along one rail as shown by the arrows in Fig. 115 to the connection to the relay, along the wire which connects the relay to the rail, through the coils of the relay, down the wire connecting the relay to the other rail along the other rail, in the opposite direction, to the wire which connects it with the other pole of the battery and back to the battery.

The passing of this current through the coils of the relay energises them.

So far we have a simple track circuit.

In the condition described with the relay picked up, suppose a pair of wheels to enter the section as shown

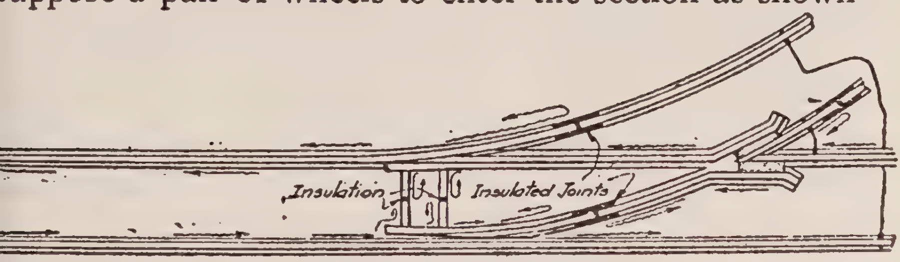


Fig. 116.

by the dotted lines at D, Fig. 115.

The wheels and axle, being of large mass, offer an infinitesimal resistance to an electric current, while the relay coils are wound to offer quite an appreciable resistance. The bulk of the current, as is always the case, takes the path of least resistance and goes across through the wheels and axle.

This de-energises the relay coils, as there is not enough current left going through them to hold up the armature, which falls away by gravity into the position shown at C, Fig. 115.

If the circuit from another battery is connected in such a way that one pole is attached to the hinge of this lever and the other pole to the front contact point, when the relay is picked up this circuit

is closed and a current will flow through it, when the relay is down this circuit will be broken. The relay, therefore, acts exactly like a push button which, when one pushes down on it, closes the circuit and lets current flow through it. When it is released the spring, instead of gravity as with the relay, throws the contacts apart and breaks the circuit.

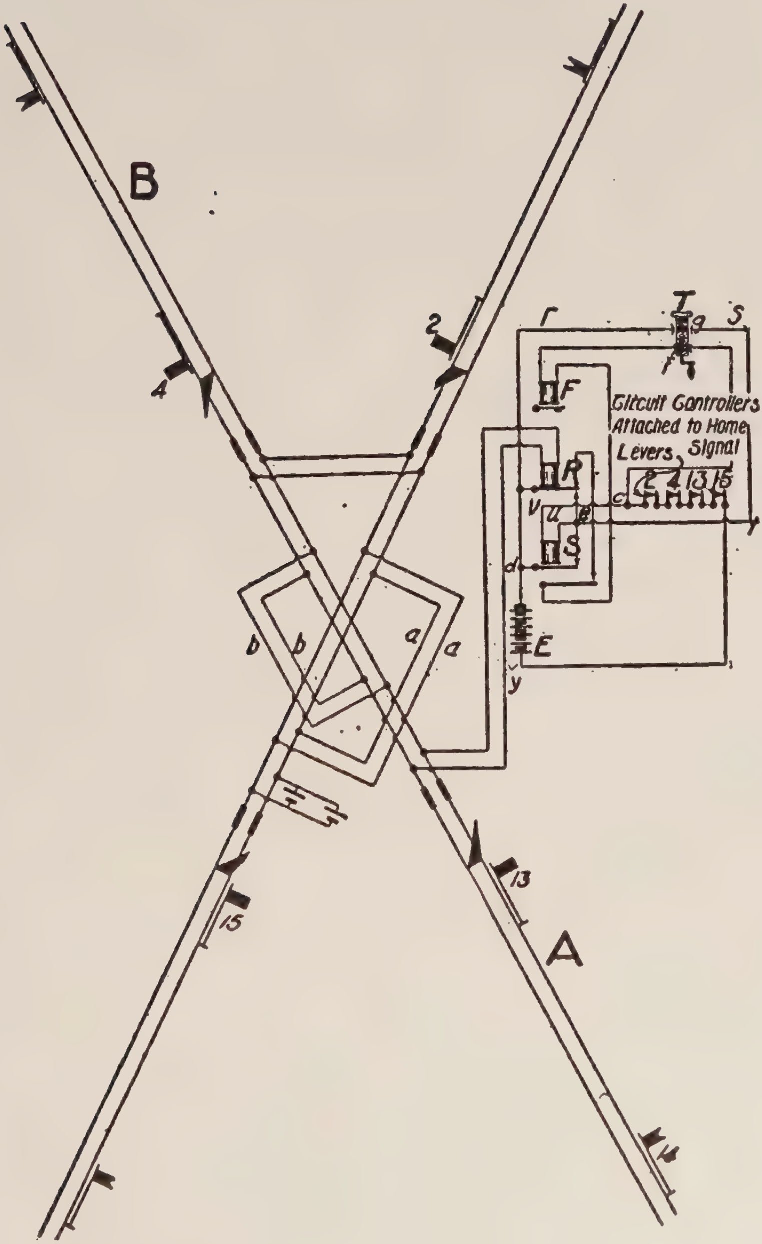
The foregoing is all there is to a track circuit. Where switches come into a section, special provision has to be made to insulate them in such a way that the current from the track battery will not cross from one rail to the other through the switch rods.

Fig. 116 shows a typical way of doing this.

We will now go on to consider the application of a track circuit to electric route locking.

There are numerous ways in which the principles of electric locking may be applied to an interlocking plant. One of the earliest methods adopted and that from which more elaborate arrangements have been evolved is illustrated on page 261. Here the track circuit extends from one derail to the other in each line, being carried around the crossing itself by long bond wires a a b b. R is the track relay which is common to either line. E is a local battery, usually placed in the tower, circuit from which passes through the front contact of relay R, and from there through a front contact of another relay S, from thence it goes through the coils of the electric lock F, and from there through a connection in a hand release T, the use of which will be explained further on, and back to the point c, whence it passes through circuit controllers attached to the home signal levers, and back to the battery.

It should be remarked that just after leaving E the current is divided at a point d. We have just traced out the path of the current which goes through the front contact of relay R. We will now follow that part of the current which leaves the former circuit


B
A
2
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F
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V
u
e
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d
y
b
b
a
a
Circuit Controllers
Attached to Home
Levers.
Signal
2 4 13 15

at d. This, it will be noted, has a path through another front contact of relay S, to point e, through the coils of relay S to c, and back to battery. This part of the current, therefore, serves to energise relay S. A peculiar condition exists here, which should be carefully noted. That is, that the circuit by which relay S is energised is completed by its own front contact. Now when the leverman reverses home signal lever 13, in order to give the route A-B, he breaks circuit through lock F, which is placed on derail lever 4, and locks that lever reversed, and also the circuit through relay S, which drops its armature. Relay R, however, holds up until the first pair of wheels enters the track section, when it drops. Now if the leverman restores lever 3 to normal while some part of the train is still in the track section, he closes circuit through relay S *by way of the back contact of relay R.* This causes relay S to pick up. In this position as soon as the last pair of wheels passes out of the track section relay R picks up; this completes the original circuit through lock F, so that the lock picks up, thereby releasing derail lever No. 4, which may then be returned to normal, and the plant is ready for a movement through it in any direction.

If the leverman should fail to return his home signal to normal until after relay R has picked up, he must use his hand release in order to get his derail lever normal again.

These hand releases are made in many ways. Sometimes they are an ordinary electric switch, enclosed in a glass case, which is sealed so that the seal or glass must be broken every time the release is used. When one has been broken open the leverman is required to make a report of the circumstances. This has a tendency to make the levermen careful to return the home signal levers to normal as soon as a train passes the signal, especially as the hand release is most often

placed in the lower story of the tower, so that the leverman must go down stairs to get at it.

Another quite popular design is what is known as a screw hand release. These are generally attached to the side of the interlocking machine. They are operated by a long screw with a crank on one end which takes about a half minute to screw in to its full length. When screwed in it operates a piece of mechanical locking so as to tie up the machine and must be screwed out to its normal position again before the machine is unlocked.

There are two contact points in the hand release, shown in the figure on page 261., as f and g. The former is closed when the hand release is normal and the latter when it is reversed. At all times only one point is closed and the other open. When the leverman reverses his hand release, he closes contact at g. This completes a circuit from d to r, g, s. t, u, v, c, through relay S, energising it. After it is once energised it holds itself up through its other front contact, attention to which arrangement was called above.

This is what is known as a *stick relay* arrangement. In making contact at g the leverman has broken contact at f, which is in the electric lock circuit, and, therefore, the electric lock F does not pick up until the hand release is returned to normal.

In case a leverman sets up a route for a train by mistake, and then wishes to change it, he must resort to the use of the hand release, as above, in order to unlock himself.

Another popular form of electric locking is to use a so-called interlocking relay in the circuit.

An interlocking relay is one which has two sets of coils, being in reality a double relay. The armatures are so interlocked with each other (hence the name), that whichever of them drops first will mechanically hold up the other, even after its coil is de-energised.

Two interlocking relays are used at a plain crossing, one for each line, and each line is divided into two sections ending at the crossing, each with its own track battery, usually placed beyond the distant signals. One coil of the interlocking relays acts as track relay for one section and the other as track relay for the other section. As soon as a pair of wheels passes the battery end of the section, most often five hundred feet beyond the distant signal, the side of the interlocking relay connected to that section drops.

This breaks the lock circuit and locks the derail lever. As soon as the first truck passes over the crossing, the other side of the relay becomes de-energised, but its armature cannot drop because the armature of the other magnet holds it up. As the last truck passes out of the section on the approaching side of the crossing, that side of the relay picks up again, but its armature still interlocks that of the other side holding it up. This closes the lock circuit as soon as the rear of the train is over the crossing and releases the leverman without making him wait until the rear of the train has passed beyond the distant signal on the far side of the crossing. Hand releases are not generally used with this arrangement, although they are sometimes put in. In such an arrangement the track circuit is usually looped through a circuit breaker attached to the arm plate of the distant signal, so arranged that when the signal is set at clear the corresponding magnet in the interlocking relay is de-energised just as if a pair of wheels had entered the section. In this case setting the distant signal at normal before a train has entered the section causes the interlocking relay to pick up again and energises the lock.

Fig. 117 illustrates a single track crossing with an interlocking relay arrangement as described for the electric locks.

Where power distant signals are used, the same cir-

cuit which is used for the back lock may also be used for the electric locking, by putting in a track circuit.

An arrangement of this sort is shown in Fig. 118.

The operation of this arrangement is as follows: The leverman, of course, first reverses the derail

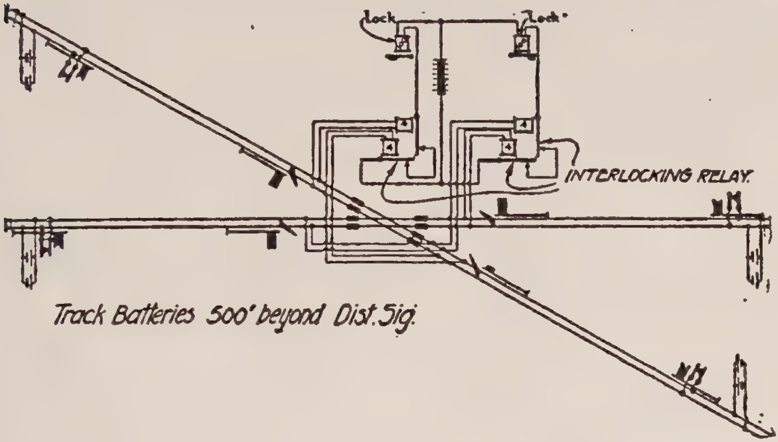


Fig. 117.

lever, next the home signal lever shown as No. 2 in the figure, and lastly the distant signal lever shown as No. 1.

What we wish to accomplish is this:

(1) Whenever the power distant signal is reversed the home signal lever must be locked half reversed.

(2) Whenever a route has been set up in error it cannot be changed unless, either a train has passed through the track section, or the leverman has resorted to the use of the hand release.

(3) Whenever a pair of wheels is in the track circuit, which in this arrangement extends between the derails, the lock to be de-energised locking the home signal lever half reversed even after the distant signal is returned to normal. But after the pair of wheels has passed out of the circuit, the lock to pick up so that the home signal may be restored to normal, thus releasing the derail lever.

The circuit by which the first of these is accomplished is as follows:

When home signal No. 2 is reversed, circuit controllers A, which is on the machine, and B, which is attached to the arm plate of the signal, are closed, and when distant signal No. 1 is reversed circuit controller shown as C is closed. Current then flows from the local battery in the tower along wire a a a a ——a, through relay R, which is the control relay at the signal, to the common wire and back to battery.

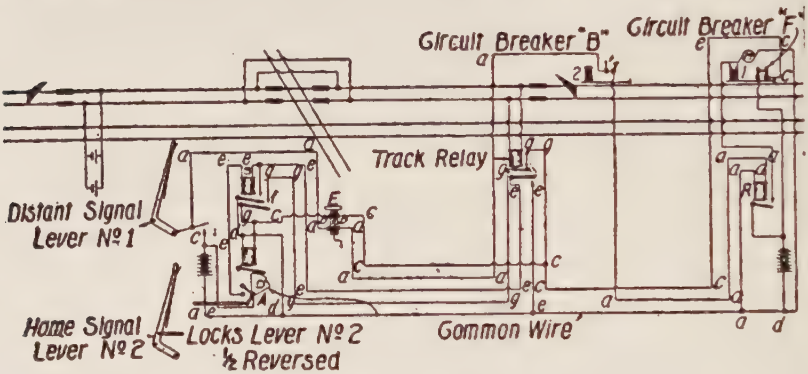


Fig. 118.

This energises relay R, which picks up and closes circuit from the local signal battery through signal motor M, which revolves and clears the signal.

All this time the electric lock D, which does not prevent the lever from being reversed, is down, so that when the home signal lever is reversed, it cannot be set normal again; thus the back locking is accomplished and more than accomplished, as even if the distant signal is set normal again it will not release the home signal without the use of hand release E.

By reversing this hand release so as to make contact between points b b, current will flow from the local signal battery along wire c c c——c, through circuit controller F, which is attached to the arm plate of the distant signal and which, it should be noted, is

only closed when that signal blade is normal, to hand release E across b b, through the electric lock and back to common via d d.

Now for our third problem. The route being set up a pair of wheels passes the home signal and the track relay drops. This closes circuit from the local battery in the tower through stick relay S, by way of e e e ——e, and back to common. Stick relay S therefore picks up closing front contact point f, so that as soon as the train passes out at the other end of the track circuit and the track relay picks up circuit from the battery at the distant signal through c c c c c c c g g g g is closed through the lock magnet, releasing lever No. 2, which can be then set normal, breaking circuit through the stick relay at circuit controller A, and everything is restored to normal.

Although I have referred only to crossings in this description of the application of time and electric locking to interlocking plants, what I have said may equally well be applied to junctions, crossovers or switches.

One use of electric locking which has come quite prominently into vogue of late years is as a substitute for detector bars.

Rail of large section, 100 pounds per yard or over, has such a wide head that mechanical detector bars, especially if link clips are used, cannot be depended on to strike the tread of a wheel which is over the bar. Where such rail is used short track circuits, generally 100 feet long, are put in at derails and switches and electric locks applied. There is no essential difference between their application for that purpose and for any other. Neither is there any essential difference when electric locking, as is frequently done, is applied to a power interlocking plant. The locks themselves, as before explained, are made in a variety

of ways. Some fit better to Saxby and Farmer locking and some to vertical locking.

Each relay or magnet coil of any sort in a line wire should be protected by what are known as *lightning arresters,* one in each wire connecting with the coil, placed near the magnet.

There are many forms of these devices. The principle on which they operate is to have the operating circuit, by being carried through them, placed so close to a low resistance point or collection of points which is connected with the earth, that in case of a very heavy static charge being collected in the line wire it will jump the gap between the regular circuit and the points and find its way to earth without passing through the magnet coils and burning them up. The regular operating current being of too low pressure to jump the gap, no interference therewith is effected by the lightning arrester under normal conditions.

The side of the lightning arrester, which is connected to earth, should be attached to a heavy copper wire, No. 8 at least, which in turn should be securely fastened to a *ground rod* driven deep enough into the ground to insure contact with permanently damp earth. Sometimes, where grounds are particularly hard to get, it is necessary to bury a copper plate for this purpose.

There are a great many places on every railroad where there are outlying switches, or crossovers at which it would be impossible to put in complete interlocking plants, but which are so situated that they need more protection than can be given by an ordinary switch target.

Very efficient protection may be had at such places by putting up signals operated by a lever stand and interlocked with the switch in such a way that unless the switch is set in the proper position for the main line the signals must be at caution or danger. Gen-

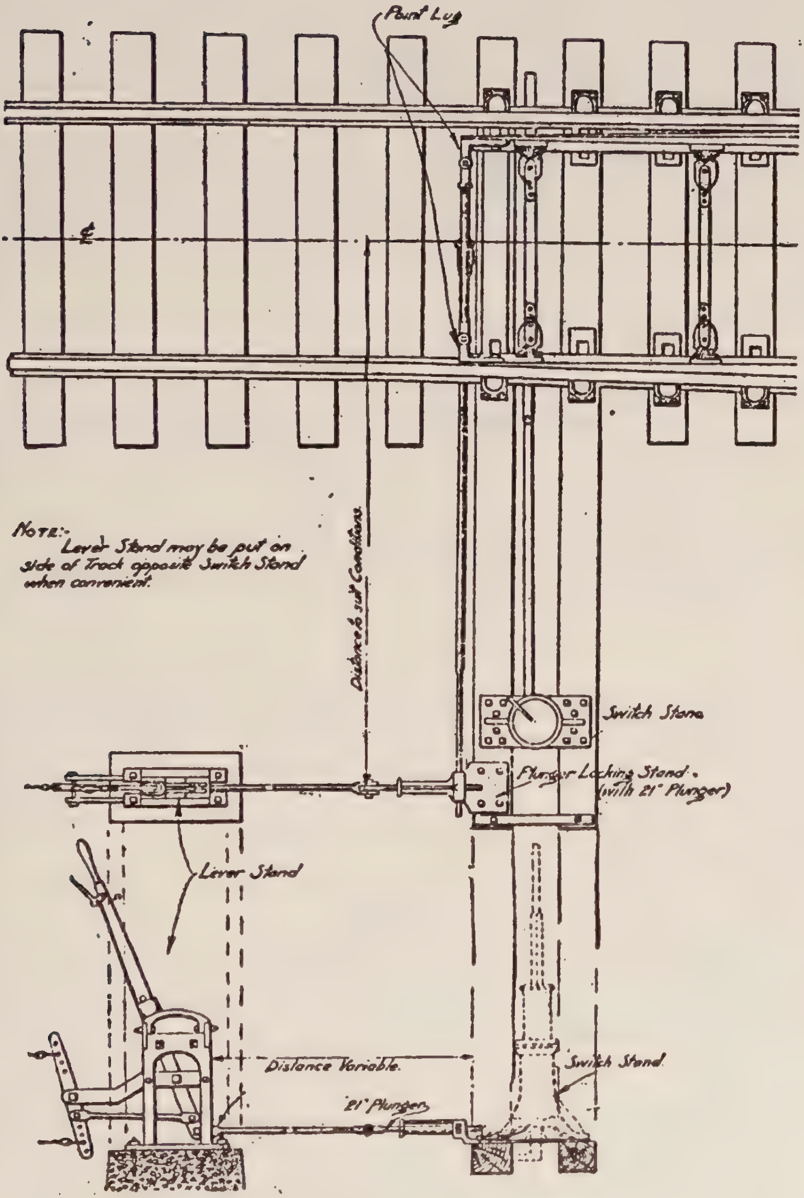

Point Lug
℄
Note:-
Lever Stand may be put on side of Track opposite Switch Stand when convenient.
Distance to suit Conditions
Switch Stand
Plunger Locking Stand.
(with 21" Plunger)
Lever Stand
Distance Variable.
21" Plunger
Switch Stand

Fig. 119.

erally it is sufficient to put in a distant (caution) signal only and to depend on the switch target for a home signal, but in other cases, especially at trailing point crossovers, it is as well to put up both home and distant signals and to dispense with the switch target and lamp.

The interlocking may be accomplished by using a common bolt lock or by equipping the switch with a facing point lock, the plunger of which is attached to the lever which operates the signal, as shown in detail in Fig. 119.

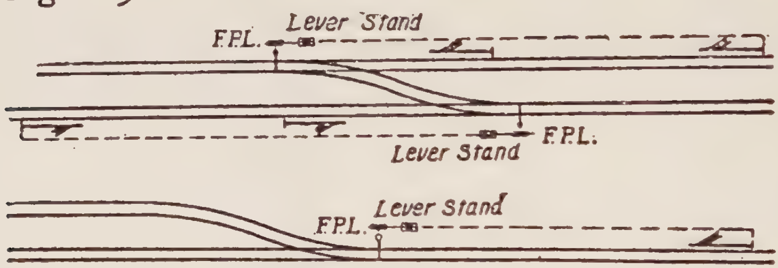


Fig. 120.

In such cases the signals stand normally at clear. The switches are operated by the ordinary switch stand, but on account of the interlocking the signals must be set at caution and danger before the switch can be thrown.

Fig. 120 shows a facing point switch and a trailing point crossover so protected.

Such arrangements are frequently used on the railroads of Continental Europe, and a report bearing on them, issued by a committee of the International Railway Congress a few years ago, is very interesting reading. They are not, of course, to be classed with complete interlocking, but nevertheless a great deal of security may be had for very little money by their use. The signals are most frequently wire connected. Electric signals, operated much as power distant signals are, may, however, be used, a circuit

controller being attached to the lever by which the facing point lock is operated.

With such arrangements trains using the switch or crossover must pass the signals at stop or caution, which by some is considered bad practice, but as a trainman is at the switch to give hand signals when such movements are to be made, this objection does not apparently carry much weight, and where no home signal is used is unworthy of any consideration whatever.

CHAPTER XVIII.

NIGHT INDICATIONS — MANUAL BLOCKING — CONTROLLED MANUAL BLOCKING—ELECTRIC SLOTS.

We next come to the question of night indications. This is one of the most, if not the most, vexatious problems with which the signal engineer is confronted. During the hours of daylight, the semaphore makes an ideal position signal, but as soon as darkness closes in we have to give up the position and fall back on a color indication.

The only really satisfactory lights which can be seen and distinguished at any great distance are red, green and so-called white. As the white light is in use for every sort of illuminating purpose at night, both on and off railroads, its use for railroad signaling is objectionable. It is considered absolutely necessary that we give three indications:

Proceed without limitation.

Proceed cautiously.

Stop.

From time immemorial a red light has been used as a stop signal on railroads. In England, from the earliest, green was adopted for clear, and English railroads have simply done without a night caution indication (their distant signals showing red in the caution position), depending on their engine runners' bump of location to distinguish a distant from a home signal.

Quite a number of years ago the Chicago & Northwestern Railway adopted green for clear, and, in default of anything better, uses a double light red and green side by side for a caution indication. Up until this step was made by the Northwestern, it had been the universal practice in this country to use white lights for clear and green for caution. This practice was continued by most railroads for some time, but within the past five years many of them have adopted green for clear and an orange yellow for caution.

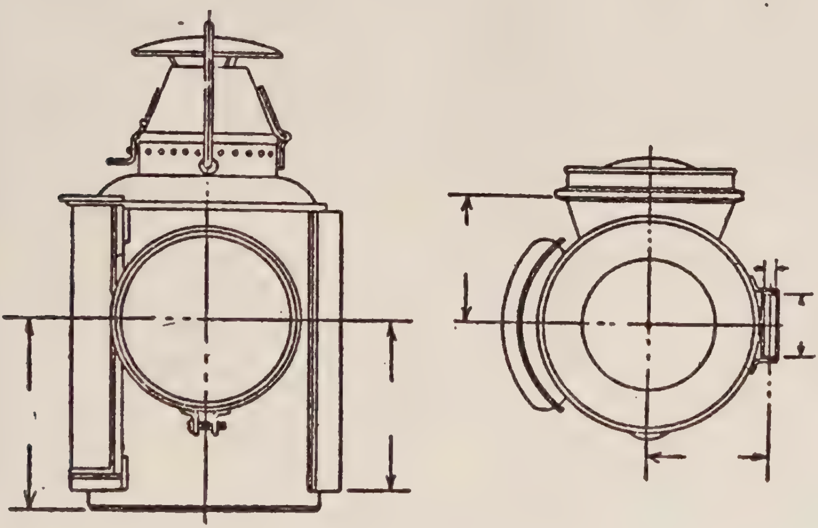


Fig. 121.

This latter appears to be the best single light yet proposed, but still it is far from being as distinct a color as either red or green.

A very serious objection to the use of white for clear is that as the lamp itself gives out a white light, this will show through the arm plate if a colored roundel should be broken out, so that a clear signal may appear to an engine runner when a stop or caution signal is intended. It is remarkable that accidents

do not happen from this cause more frequently than they do.

The almost universal type of semaphore lamp is shown in Fig. 121. This has an uncolored glass magnifying lens through which the light from an oil or incandescent lamp shows in its front. This lens is 5⅜ inches in diameter. A plain bull's eye about two inches in diameter is most frequently placed in the back of the lamp. The focal point of the front lens is arranged to fall in the flame of the lamp. A

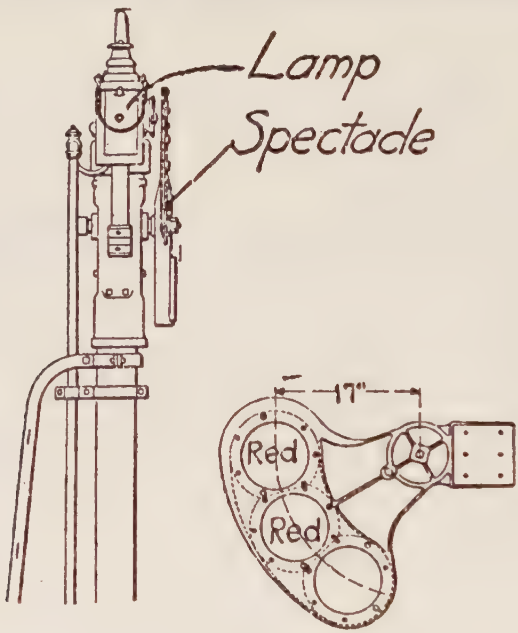


Fig. 122.

bracket or hook is attached to the side of the semaphore pole near the top and a sleeve in the side of the lamp fits over this hook, holding the lamp in place.

The semaphore arm plate has plain colored glass called roundels let into it, which are moved in front of or away from the lens in the lamp as the arm plate changes its position. For instance, a home sig-

nal with the blade horizontal will have a red roundel in front of the lens. If green is the color for a clear indication a green roundel will be moved in front of the lamp when the arm plate assumes the clear position. If white is used for clear, no roundel is brought before the lens in the clear position of the arm plate, and the lens of the lamp itself gives the clear indication.

A glance at Fig. 122 will serve to make this description clearer.

Sometimes what is known as a continuous light arm plate is used. This is shown in Fig. 122. It will be noticed that there are two red and one green roundels in this casting. The object of this is to have the signal show red until it is in the full clear position. In case the connections are loose and the blade droops, the signal will not give a false clear indication.

The back light is used so that the leverman in the tower may be able to tell whether or not the lamps in signals which face away from him are burning, and whether the signals respond to the movement of the levers. A small attachment called the back light casting, of which mention has already been made, is attached to the spindle and works behind the lamp. This carries a small roundel, usually purple or blue, through which the light shows when the signal is normal; the white bull's eye showing when the signal is reversed. Signals which face the tower, and those which cannot be seen from the tower should have the back lights blinded by soldering a piece of tin over the bull's eye, or painting it over on the inside of the lamp.

Fig. 123 shows one of the Chicago & Northwestern's caution signal lamps. In the back of the extension is a looking-glass reflector which throws the light from the burner through the plain green glass. The

lamp proper is fitted with a red lens instead of a white one. No roundels are used in the arm plate. When in the horizontal position the red lens is exposed to view. When in the clear position a metal

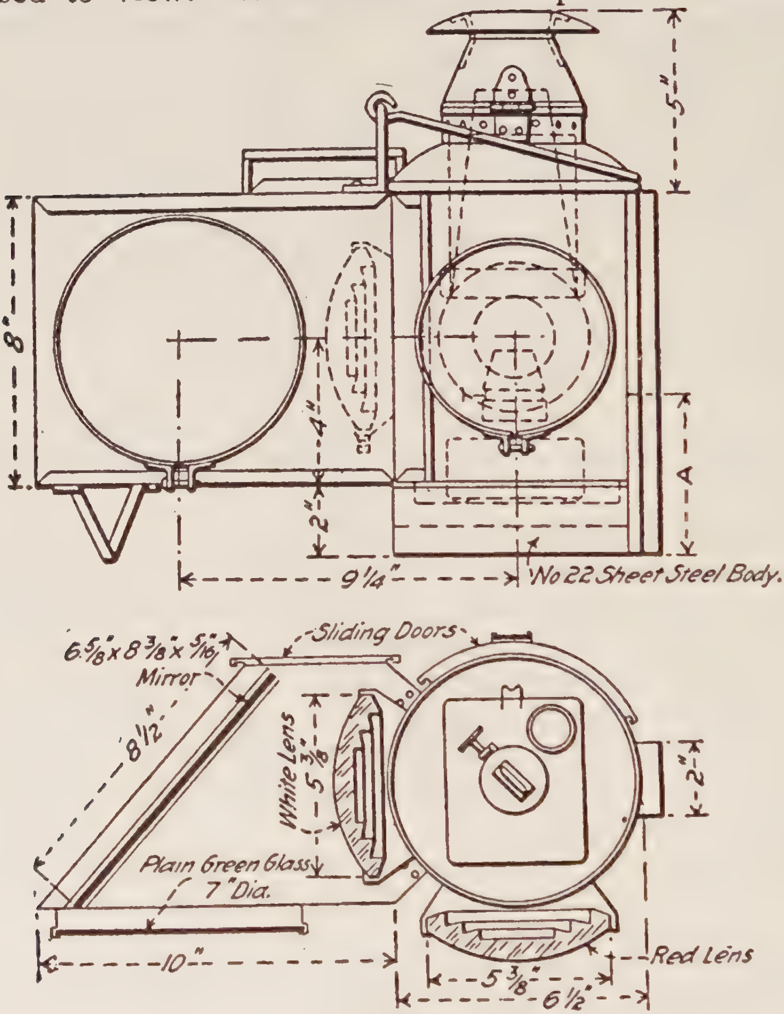


Fig. 123.

disc is moved before it so as to obscure it, leaving the green light alone visible. One burner is used so that in case the lamp should go out, both lights will be extinguished. If two separate burners were used,

the one in the red lamp might go out, leaving the green light showing, which would give a clear instead of a caution indication, as intended.

So far we have had in mind two position signals only. Three position signals usually show a red light at horizontal, a green or yellow light at inclined 45 degrees, and a white or green light when vertical. This is determined by the shape of the arm plate, and there is no difference worthy of note between them and the two position, so far as the operating mechanism is concerned.

One serious objection to the present system of night indications is that men whose vision is affected by color blindness are apt to make mistakes in reading the colors. Any man whose range of vision is normal can see the positions of a semaphore blade in daylight, even though he may not be able to distinguish red from green, or vice versa, at night. Efforts have been made from time to time to develop an illuminated semaphore blade, but it cannot be said that up to the present they have been crowned with any success. It is a fact that I have noticed in riding on engines at night, that where powerful electric or acetylene headlights are used, it is often possible to see the position of semaphore blades as distinctly as in daylight, and it may be that some special design of headlight may yet be attempted for this purpose.

A great deal of attention was attracted some years ago to the so-called long time burner. This is a burner designed to be used in a kerosene lamp, which consumes so little oil that it may be left burning for several days without any attention, and yet will give out sufficient light for a signal lamp. The first enthusiasts claimed a little too much for these burners, declaring they did not need attention for a week at a time. This did not work out in practice, and a reactionary feeling was developed against them, which

went as far in the other direction. My experience has been that where they are looked after and the crust removed from the wick every second day, they will give very good results.

Some attempts have been made, with more or less success, to light signal lamps by acetylene or ordinary illuminating gas. The latter is frequently done abroad.

The American Railway Association has defined a block as being "a length of track of defined limits, the use of which by trains is controlled by block signals."

A block signal is one used solely to warn a train that it is safe or unsafe for it to proceed into the block which that signal governs. There is a general tendency to use semaphore signals of much the same design as those used for route signalling as block signals, although flags, discs and hand lanterns are occasionally used.

The simplest form of blocking now used in this country is the so-called *Telegraph Block*.

We have, we will say, two stations, A and B. They are in communication with each other, either by telegraph, telephone or electric bells. A train comes up to A, moving in the direction of B. The operator at A signals the operator at B that he has a train he wishes to admit into the block; B signals back his acquiescence, and A admits the train either by clearing a signal, notifying the train crew verbally, or in writing, or by some other means. Now until that train reaches B, the operator there is supposed to hold his signal for a movement from B towards A at stop, and to clear it for nobody (we are supposing a single track line) until the train which A operator has admitted has passed B. A in the meantime sets his signal at stop behind the train and will not clear it again without B's permission. If B wants to admit a train from his end he has to get A's permission.

Now, this is all very easy and simple, and as long as nobody makes a mistake trains may be moved with perfect safety and with great dispatch in that way, provided they have a chance to pass each other when they meet. But if B forgets about having let A admit a train and lets one in from his end, or if A forgets to restore his signal to stop and then goes to sleep or drops dead, and if the train he had admitted should be forced to stop in the block and another one following it should find the clear signal at A and go on, very serious consequences may result.

However, the ordinary manual block system is just exactly what has been described, and it has done and is doing good work every day on thousands of miles of American railroad.

Where only one train is allowed in a block at one time, it is known as *absolute* blocking.

It is, however, more frequently the rule than not, at least as regards freight trains, to allow one train to follow another into a long block before the first one has been reported out at the other end, the crew of the second train being warned before entering the block that there is another train ahead of them. Where this is done, it is known as *permissive* blocking.

As before stated, semaphore signals are most frequently used for manual block signals.

Some roads distinguish their block semaphore signals from their route signals by sawing off the corners of the blade at the end farthest from the mast, so as to point the blade; some paint them differently from route signal blades, and some make no distinction between them.

In American practice the ordinary commercial stations are used as block stations, as well. The operators usually have a room with a bay window extending out into the platform, so that they can see up

and down the track. The semaphore is usually placed in the platform just outside of the bay window, or if the view is obstructed by water tanks, elevators or trees, it is often placed across the track. Semaphores

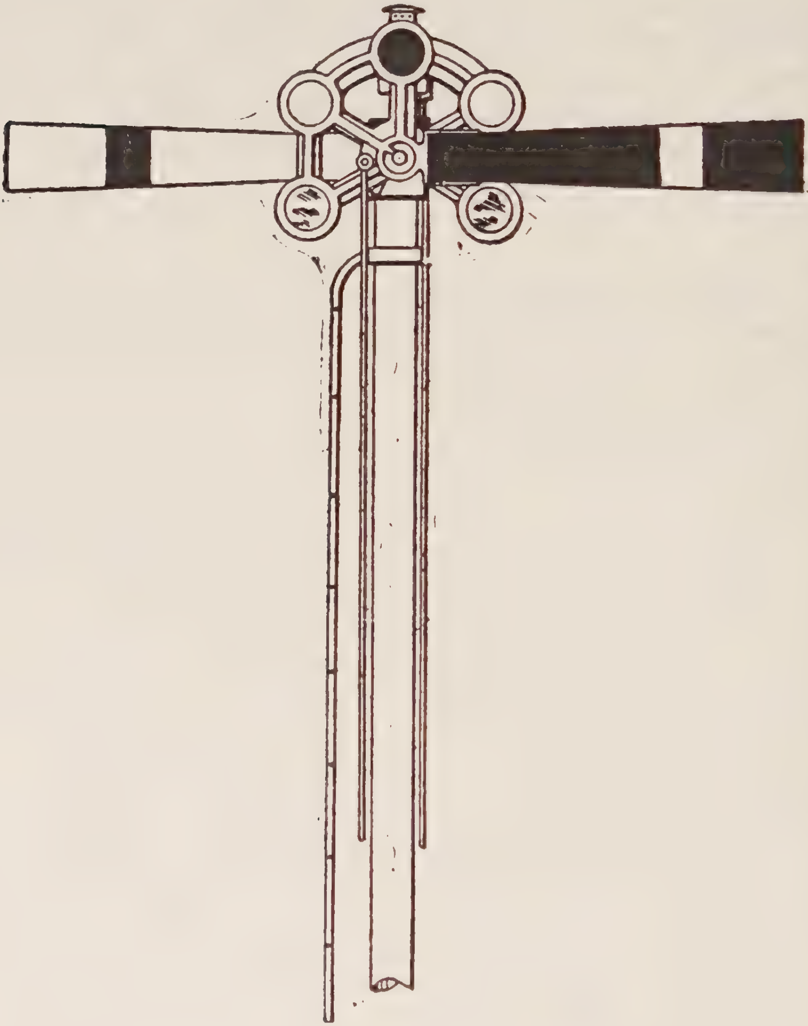


Fig. 124.

used for such purposes most frequently have two blades, one to govern the block at one side of the station, and one to govern the block on the other side.

See Fig. 124 for a typical illustration of such a signal.

These signals are sometimes wire connected and sometimes pipe connected. The best practice is to pipe connect them, as they are very important signals. Levers of some sort are placed in the operator's room, so as to be easily within his reach, by which the blades are operated. There is no uniformity of practice as to the construction of these levers. A great many railroads make them in their own shops, and every imaginable design of wheel pulley and lever are to be found in use.

Where a semaphore signal such as described is used, the arm plates are so arranged that only one lamp is necessary. This is in all essentials the same as the lamp just described, except that it has two 5⅜-inch lenses opposite each other, instead of one lens and a small bull's eye.

Manual block signals are, like route signals, kept normally at stop and cleared only to allow a train to pass.

Where permissive blocking is in use, crews of following trains are given warning that another train is in the block ahead of them by signal or by the use of so-called caution cards.

There is not much uniformity in the signals used. One large company uses a three position signal, in which the blade at stop is in the horizontal position, at clear is inclined downward 45 degrees, and at caution is inclined upward 45 degrees.

Another company uses a home and distant signal on the same mast, home above and distant below. Both inclined downward at 60 degrees indicates that the block is clear. Both horizontal indicates stop, and the upper blade inclined downward with the lower one horizontal indicates that a train may enter the block permissively.

The American Railway Association has recommended a standard form of caution card which is very generally used, so that as far as the use of caution cards is concerned, practice may be said to be uniform.

In the ordinary telegraph block which we have just been discussing, there is no surety that A will ask B for permission to admit a train or that B will not

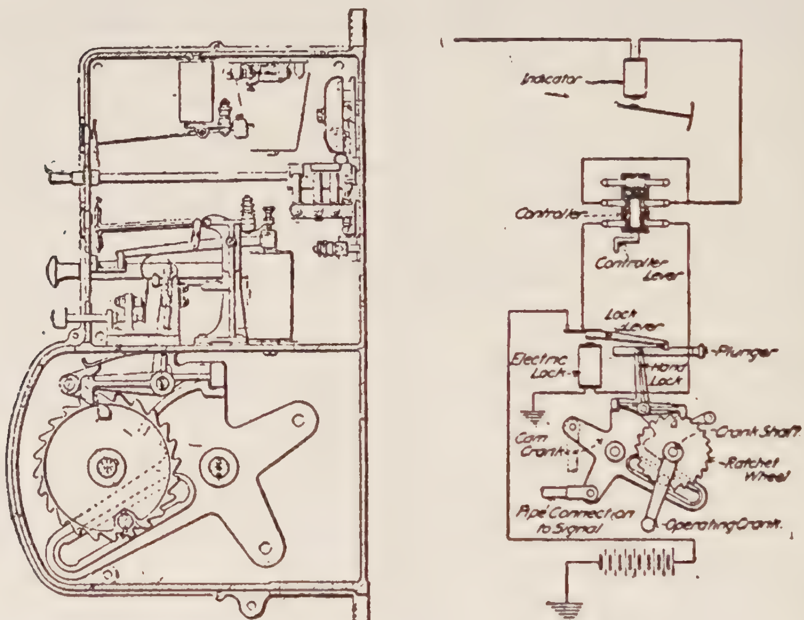


Fig. 125.

admit a train from his end after A has admitted one from his. Mistakes of this sort have been made and have been the cause of some very costly accidents. This brought out the idea of electrically connecting A and B in such a way that A could not clear his signal unless B first unlocked it for him. Such an arrangement is known as the *controlled* manual block. There are several sorts of apparatus designed for

this purpose on the market, any one of which will accomplish the desired result. Fig. 125 shows a very popular type of instrument gotten out by the General Railway Signal Company. The cranks act as levers to operate the signal blades. By a simple arrangement of electric locks, shown in the sectional view, the crank connected to A's signal cannot be moved unless both A and B at the same time hold circuit breakers in their respective instruments closed.

The use of such instruments insures that the operators at either end of a block communicate with each other before admitting a train, but the train once in, either of them can call on the other for an unlock, and if the man called on forgets himself and gives it may admit another train. This is guarded against by carrying a track circuit entirely through the block and cutting the wire which connects the two instruments through the front contact of the relay of every section in the block.

Then so long as any relay is down, and one or more must be down while there is a train in the block, the wire by which A and B unlock each other is broken and neither can unlock the other.

Very frequently the passing tracks at stations are so long that their far ends are quite a distance from the station.

Trains on passing tracks, waiting to be passed by other trains, have been known to pull out on the main track at the far end of the passing track, when they should not, and thus get into the block at a time when the block operators supposed it clear. In order to put these switches absolutely under the control of the block operator, they are often locked with electric locks, which are put under his control.

These refinements are mostly in an experimental stage still, and there is no uniformity about the devices used.

Theoretically no doubt they, like electric locking at interlocking, add greatly to the safety of a block system, but in practice, with the frequent interruptions caused by their getting out of order, it is doubtful whether they add much real safety.

Controlled manual block is often called *lock and block*. One great trouble with all lock and block instruments yet designed is that the men can beat them if they make up their minds to do so.

A great mistake is always made if, when any such apparatus is installed, the men who operate it are given to understand that the device cannot be beaten. This puts them, many of them having unlimited time at their disposal, on their mettle to find out why it cannot be beaten, and some unrecognized genius is certain to discover the secret sooner or later. It is much better to tell the men plainly at the start that the apparatus can be tampered with if they want to, but that it is put there for their own protection, to prevent their making hasty mistakes, and they had much better try to keep it in good working order.

A very simple and reliable system of controlled manual block is what is known as the electric train staff.

The present staff block system and apparatus is an evolution from a very crude and very early block system.

When the Stockton & Darlington Railway, which was the first road to be opened as a public commercial enterprise, commenced to do business, it was soon found that trains would meet each other between stations (the line was single track). As a large part of the traffic of this line was moved by horses, and even when locomotives were used, their speed did not exceed eight miles an hour, there was no great danger of collision, but one or the other train had to back up until a passing track was reached. This made

serious delays, especially as the crews of the meeting trains usually quarreled as to which had the right to proceed and which must back up. To overcome this last difficulty, the railroad company had posts put up midway between passing tracks. Whichever train reached the post first had the right to proceed, and the other was compelled by the rules to back up and make way for it. As speed and the number of trains increased, and it is to be remembered that the ten years following the opening of the Stockton & Darlington saw wonderful progress in railroad improvement, this arrangement was found to be impracticable. The next step, therefore, was to provide a talisman, or sign, the possession of which gave the train holding it the right to proceed, while all other trains, as there was only one for each block, were forced to stop and wait for the train having possession of the talisman to pass through the block. A staff was used for this purpose, from which the system has acquired its name, although the insignia now used can hardly be said to have the slightest resemblance to a staff. As long as traffic, as represented by the number of trains on the road, was equal in both directions, and as long as for every train that went north or west another train went east or south before there was a movement in either of the former directions, this worked well enough, because a train taking the staff at A left it at B, and as the next movement was from B to A, the staff was brought back again. If several trains wanted to move from A towards B before one moving in the other direction appeared, all but the first one had to wait at A until the other train came along and brought the staff back. It should be remembered that in these early days there was no electric telegraph, so that communication between stations any distance apart was impossible, except by messenger or by a system of telegraphing by using

semaphores placed within sight of each other, which, of course, was useless in foggy weather.

Various systems of dividing the staff into several parts and giving each of several trains moving in the same direction a part of it were tried with more or less success, until finally the use of the electric telegraph showed how it was possible to operate electro-magnets miles away, and a system of providing a supply of staffs at each end of the block, enclosed in cases electrically locked in such a manner that when a staff was taken out of either case the cases could not be opened again until this staff was returned to one or the other of them, was evolved. This solved the problem of irregular movement of trains so far as direction was concerned, and it only remained to perfect the apparatus. Ten or twelve years ago the staffs were a club of metal about one and a half inches in diameter and two feet long. Their weight was so great that enough force was required to overcome their inertia when picking them up to make it dangerous for men leaning out of engine cabs while the engine was moving swiftly to catch them out of cranes, and throwing them off at stations where trains did not stop was dangerous to bystanders. The staff of today is a mere round steel key of little larger diameter than a lead pencil, and five or six inches long.

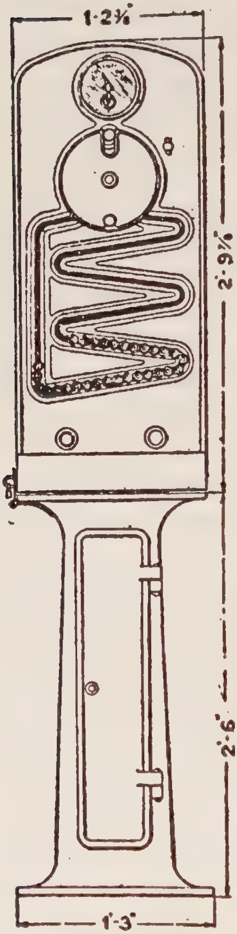


Fig. 126.

Fig. 126 illustrates a modern staff instrument.

With these instruments, not only is it impossible

to take out a staff after one has been taken out of either of those at opposite ends of a block, but even when no staff is out, A cannot remove one without first getting B to unlock him, and vice versa.

In practice the staffs are taken out by the block operators and handed to train or engine men as they pass the block station, either by putting the staff in a leather or India rubber pouch and suspending it from a crane, something like a mail crane, from which engine men on passing trains can either pick them off by hand or by a catching device attached to the engine; or by handing them to the engine men. When the latter method is pursued, the pouch is generally made of rubber hose shaped into a ring about two feet in diameter. The operator holds this up so that the engine man standing in the gangway or leaning out of the cab window can pass his arm through the ring. I have seen them picked up in this manner at a speed of forty miles an hour, and have ridden on an engine by which one was picked up, through the means of a mechanical catcher from a crane, while we were running at a speed of sixty-three miles an hour.

Formerly it was considered necessary to divide the staff and give part of it to the engine runner and part to the conductor, as a check on each other, but in the practice of today it is thought sufficient if the whole staff is taken by the engine runner.

Where staffs are to be picked up at speed, it is customary to work them in conjunction with a block signal. The signal at proceed means that there is a staff out ready to be picked up. The signal at stop means there is no staff ready for the approaching train, and it must stop and wait until one is released. Sometimes as an extra precaution the staff itself acts as a key to the block signal which cannot be cleared

until a staff has first been taken from the case, and then used to unlock the signal lever.

If there is a switch leading into the main track between two block stations, a special staff machine can be placed there.

Any train wishing to enter the main track by way of the switch must first call up A or B and get a staff released, which neither A nor B can do if a staff is already out between them. On getting the release the train man of the waiting train takes out a staff which he uses as a key to unlock the switch. It must stay in the lock until the switch is set normal behind the train, but is all the while holding A's and B's instruments locked. After returning the switch to normal, the train proceeds to either A or B, as the case may be, and on reaching there delivers the staff to the block operator, who puts it back in his instrument, restoring the entire combination to normal, just as if the staff had come to him from the other end of the block.

A train entering the siding would use the staff which A or B had given it to unlock the switch, after which, when the switch was set normal again, the staff would be put in the special instrument and everything restored to normal.

It is customary to start out with an equal number of staffs in each of the instruments at either end of a block, but if, as is usually the case, there are more trains moving in one direction than in the other, sooner or later all the staffs will get to one end or the other of the block. It is often many days, weeks or months before this happens. The cases may be unlocked by the maintainer, who can take out staffs enough to even things up, from the bottom of the case, and carry them to the other station, putting them in the case there, without interfering with the operation of the instruments during this transposition.

Of course it is understood that the change will be made before one case or the other is completely exhausted, so that there will be staffs enough to conduct business while they are being moved.

The staffs for one block will not fit in the instruments belonging to the adjacent blocks, so that they can be used only between two given stations. For instance, if there are three blocks, A-B, B-C, C-D, there will be one instrument at A, two at B, two at C, and one at D. The staffs that work between A and B will be of a different shape from those that work between B and C or C and D. Staffs are cut, I believe, by the makers in about ten different shapes, so that every tenth block will use the same type of staff. It is thought that this distance is sufficient to insure against their misuse.

Besides the intermediate or junction staff instruments, already alluded to, an arrangement can be furnished by which a secondary staff may be taken out and given to a pusher or helping engine which only goes part way through the block and then returns to the initial station.

The regular staff is given to the through train, while the helping engine carries the secondary staff. Assuming that the train starts from A and the helping engine cuts off half way between A and B and returns to A. Now, if the through train reaches B and turns in its staff before the helper gets back to A, the block is still held by the helper through the medium of the secondary staff. B could, of course, keep the staff which was turned in to him by the through train without returning it to its case, and give it to some train going towards A, but it is unlikely that he would do so in the first place, and in the second place the train would be following the helper and would be very unlikely to overtake it before it reached A. In case the helper arrived back at A

before the through train reached B, the staff carried by the through train would hold the block even after the secondary staff was turned in by the helping engine at A and deposited in its case.

Further than this, in order to allow permissive movements of trains, the staff can be arranged as a key to a box containing a certain number of tablets. If it is desired, for instance, to let three trains move from A to B at intervals of only a few minutes apart, without allowing any train to move from B towards A in the meantime, A calls on B for an unlock, and when he gets it he takes a staff out of his machine.

This effectually ties up B. A then takes the staff and unlocks the tablet box with it. The lock of this box is so arranged that the staff cannot be removed from the lock until all of the tablets have been removed. After unlocking the tablet box, A takes out the first tablet and gives it to the first train. This authorizes it to proceed exactly as a staff does. Then he takes out the second tablet and gives that to the second train. Then he takes out *all the remaining tablets and the staff,* which he gives to the third train. The removal of one or more tablets from the box has the same effect as the taking out of a staff, so that in case A took out all the tablets the first time, his and B's instruments would remain locked just the same.

From the foregoing the reader will see that the staff system can be applied so as to cover almost any contingency which can arise in the blocking of trains, and yet for some reason which I could never fathom its use does not appear to appeal to American operating railway men. It is in general use in Great Britain and the English Colonies, except, I believe, in Canada, for single track blocking. Its operation is simplicity itself, and it is without question the safest single track block arrangement known to man. In the United States its use is confined almost entirely to protecting

dangerous blocks, like those including tunnels, single track bridges, gauntlets, or short pieces of single track connecting two double track lines.

The Southern Pacific Railway Company has over one hundred miles of line blocked in this way. Its performance, I am informed, is very satisfactory, but this, as far as I am aware, is the only case in this country where it is used, except, as above noted, to protect particularly dangerous isolated spots.

The cost of an installation, although not equal to that of automatic signals, is still considerable, especially if semaphore signals and staff cranes have to be provided. This may be one reason why its use is not more general in this country. Another reason may be that as a great deal of American railroad carries a fluctuating amount of traffic, stations are closed at certain seasons of the year and opened at others. Since the passage by Congress of the so-called "nine-hour law," by which railroads are forbidden to allow block operators to work more than nine hours out of twenty-four, it is quite common to close certain block stations one trick of from six to eight hours each day. The staff does not lend itself very readily to such an arrangement. It can be done as follows, but this means a good deal of extra apparatus. Suppose there are three stations, A, B and C, and it is desired to cut B out from 12 o'clock midnight until 6 o'clock in the morning, an additional instrument may be put at A and one at C, using a staff different from those used between A, B and C when B is in service. It is not necessary to string additional line wires, as an arrangement of electric switches can be put in by which B on going off duty will cut out his instrument and connect the line through his station; A and C by throwing switches will cut out their instruments which work with B and cut in the two extra

instruments. This arrangement prevents them forgetting to cut B in again when he comes to work next morning, as they might do if they had a separate circuit of their own, because B will cut himself in, which will disconnect the extra instruments at A and C.

Lock and block instruments and staff instruments as well can be operated for short blocks on what is known as a grounded circuit; that is, instead of having two wires between the instruments, one to carry the current out and one to bring it back again, one wire may be used, the other side of the magnets being connected to the earth. In this way the earth acts as a common wire. A telephone, too, may be put in, using the same wire which is used for the control wire of the lock and block or staff. This saves a great deal of wire and consequently reduces the expense of an installation. What are known as *dry battery* cells, too, may be used. These are cells in which the electrolyte is made into a stiff paste so that it will not spill out. These cells are convenient to handle and do not require much room. They have a high voltage also. Their life, however, is less certain than that of a Lalande cell, and cells may fail at unexpected times. The first cost of dry cells is much less than that of Lalande cells, but as they cannot be renewed, there is no great economy in their use. The only advantage is, as before stated, in the fact that they are clean to handle and require very little space to be "set up" in.

A use to which track circuits are sometimes put is to operate semi-automatic signals. What are known as electric slots are applied to mechanical signals for this purpose. Two sorts of slots are in general use. One known as a spindle slot is attached to the spindle of a mechanical signal. The slot contains an arrangement of electro-magnets energized by a local battery working through the track relay which when ener-

gized holds the arm plate tight to the spindle, so that it responds to the movement of the mechanical lever, but if the magnets are de-energized the signal blade goes to normal and will not respond to the movement of the lever, being detached therefrom.

The other type of slot is cut into the up and down rod. When the magnets are energized the up and down rod is held together in one piece, but when they are de-energized it is cut in two, the signal going to its danger position by gravity.

This slotting of signals is most frequently used on mechanical home signals at interlocking plants through which automatic block signals are carried, or for controlled manual block signals. The track circuit is so arranged that the slot magnets are de-energized and the signals go to normal after a truck has passed them a few feet. As long as a pair of wheels is in the circuit the slot magnets "refuse to hold," as it is called, and the signal cannot be cleared. After everything is out of the circuit, the lever man must restore his lever to normal, if he has not already done so, in order to "catch" the slot so that he may be able to clear the signal again.

These devices are very ingenious and are a great safeguard where used, as the presence of a train in the section sets the signal at stop, while it requires the action of a human agent to clear it.

Their use with manual block signals prevents the possibility of an operator forgetting to return his signal to normal behind a train which he has admitted to the block.

CHAPTER XIX.

AUTOMATIC SIGNALS—AUTOMATIC TRAIN STOPS.

The object to be attained by the use of automatic block signals, like that of manual block signals, is simply to have a signal displayed in the stop position behind each train on a double track line until the train has gone a certain distance beyond that signal, at which time a second signal takes the place of the first one, and so on, continuously.

In the case of a single track line the same object is to be attained with the addition that at all times a signal governing movements in the direction opposite to that in which the train is moving must be displayed in the stop position, some distance ahead of the train.

It would be useless in a treatise of the scope of the present to attempt to give the reader a detailed description of each of the various types of automatic block signals in use, or of the many circuit arrangements by which their operation is effected. Volumes could be written on this head without covering the entire field.

The automatic block signal too has come into prominence so recently that improvements in its *modus operandi* are being advanced daily. Almost every signal engineer has some special method of applying the circuits, so that there is far from any uniformity of practice.

Every automatic signal arrangement now in use depends primarily for its operation upon the track cir-

cuit, the principles of which have already been explained.

The signals used are either of the enclosed disc, or semaphore type. The former represents the first automatic electrical signal to come into general use, and

Fig. 127.

Fig. 128.

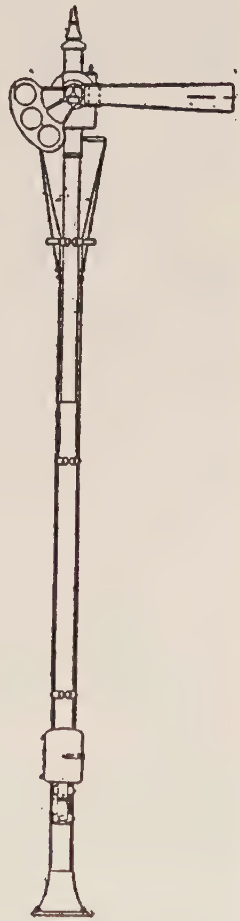


Fig. 129.

is an evolution from an early type arranged to operate by clock work.

Fig. 127 illustrates a common form of enclosed disc signal, the mechanism of which is very simple,

consisting of an electro magnet whose armature is attached to a lever, one end of which forms a hoop across which is stretched a piece of fine bunting or silk.

When the electro magnet is energized this hoop and its covering which forms a disc is removed from the glass covered opening in the case and a white background shows through the glass.

When the magnet is de-energized this disc falls by gravity so as to show through the glass covered opening.

With home signals, these discs are usually made of a red fabric and with distant signals of green or yellow.

The night indication is given by a smaller glass disc which moves away from or in front of a small glass covered opening at the top of the case, behind which an ordinary semaphore lamp is placed.

The movable parts of these signals being enclosed in the case which is made of dressed and matched lumber, and sheet steel is not exposed to the weather and can be made very light and the movable lever very nearly balanced. Their operation is quite reliable and they require very little repairs.

In spite of this, however, they are open to one objection, and so serious a one at that, that very few of them are being installed at the present time. This objection is that they are a *color* and not a *position* signal, both day and night. The fact that the cloth discs are displayed from behind a pane of glass makes it impossible to distinguish their color when the rays of the sun strike the glass at certain angles. Wet driving snow, too, sometimes coats the glass so that the disc cannot be seen at all.

Of semaphore signals usable for automatic block signals, there are a vast number, on the market, any one of which, if properly installed, will give satis-

factory service. As a matter of fact there is no more real difference between the various types than there is between watches manufactured by so many different makers.

The electro gas signal already alluded to as having been used to some extent as a power distant signal, is also applicable to use as an automatic block signal. In fact this is true of any type of signal which may be used for a power distant signal.

Many of these gas signals are now in use, although the tendency at present is to install nothing but electric motor signals.

The Union Switch and Signal Company manufactures a motor signal known as its "style B," in all essentials similar to the signal already referred to as being used with its all-electric interlocking. As is the case with all electric signals used for automatic blocking, it is supplied with a ten-volt motor. The mechanism of this signal is in a case at the base of the pole and motion is transmitted to the arm plate by up and down rods inside the pole.

One of these signals is illustrated in Fig. 128.

The General Railway Signal Company manufactures a signal known as its "model 5," illustrated in Fig. 129, which has the mechanism in a case at the top of the pole, the motor being geared directly to the spindle, no up and down rods being used.

With the former the repairman can inspect, oil or repair the mechanism without climbing the pole; with the latter, he must climb the pole to do so.

The General Electric Company and the Hall Signal Company each furnish signals with "topmast" and with "base" mechanism, as well.

The American Railway Signal Company's, and the Federal Railway Signal Company's signals have base

mechanism. Opinion is divided as to which is the better type from the viewpoint of the maintainer.

There appears to be a quite general impression amongst railroad officers who are not signal engineers, that if a certain make of signal is decided on, the same manufacturer who furnishes the signal must also furnish all other parts necessary to an installation. Such is far from being the case and frequently an appreciable economy can be effected by buying the signals from one dealer, the relays from another, the battery shelters from a third, and so on.

After it has been decided what type of signal is to be used, and whether a normal clear or normal danger system is to be installed, the location for the signals themselves must be decided on. There is no satisfactory way of doing this except to draw in the signals on a small scale map of the line, spaced an even distance apart, this distance or length of block being determined on beforehand. Then check this with a profile showing the grades, so as to prevent as much as possible placing signals in such situations that a train stopped by one will be on an ascending grade so steep that it will be impossible to start the train again. Curvature also should be taken into consideration and signals placed so that there will be as much straight track as possible in front of them, in order to give the runner of an engine a chance to see the position of the signal from some little distance as he approaches it. After the signals have thus been sketched in on a map, the signal engineer with some operating officer of the division on which the signals are to be placed should personally visit the ground and see if there are any physical reasons why it would be inadvisable to place the signals as shown. An examination of the ground frequently shows that the view of the signal will be better if it is moved a few hundred feet one way or the other.

The exact position of switches and station buildings, too, should have considerable bearing on the question of where to place automatic block signals.

For example, if there is a facing point switch in the main track and an automatic block signal is to be placed anywhere in its vicinity, it is always better to place it from 1500 to 3000 feet in front of the switch and by connecting a circuit controller to the switch points, have the signal held at danger so long as the switch is not set for the main line. Circuit controllers (switch boxes) are attached to every switch in automatic territory, so that if any of them facing or trailing is open the signals will be held at stop.

At stations it is always well to have a block signal in advance of the station building, so that the engine runner of a train stopped at the station will have the signal in front of him. If the block in advance is occupied, and the signal is in the stop position the engine runner can see it, and will not start out until the signal goes to clear, or until the limit of time which he must wait before passing the signal in the danger position has expired. If the signal is not in view from the station he might start up and then have to stop again on reaching it. In terminal territory where traffic is very heavy and the movements are not very fast, it is frequently advantageous to have short blocks—3500 feet to 4000 feet long, or even shorter.

On some of our low grade lines freight trains containing as many as eighty cars are frequently hauled.

Most freight cars now-a-days have bodies thirty-six feet long and some forty feet long. Counting the engine and caboose, these trains, therefore, approximate thirty-five hundred feet in length. Where trains of this size are frequently hauled it does not, of course, pay to make the blocks any shorter than thirty-five hundred feet, as such trains would then hold two

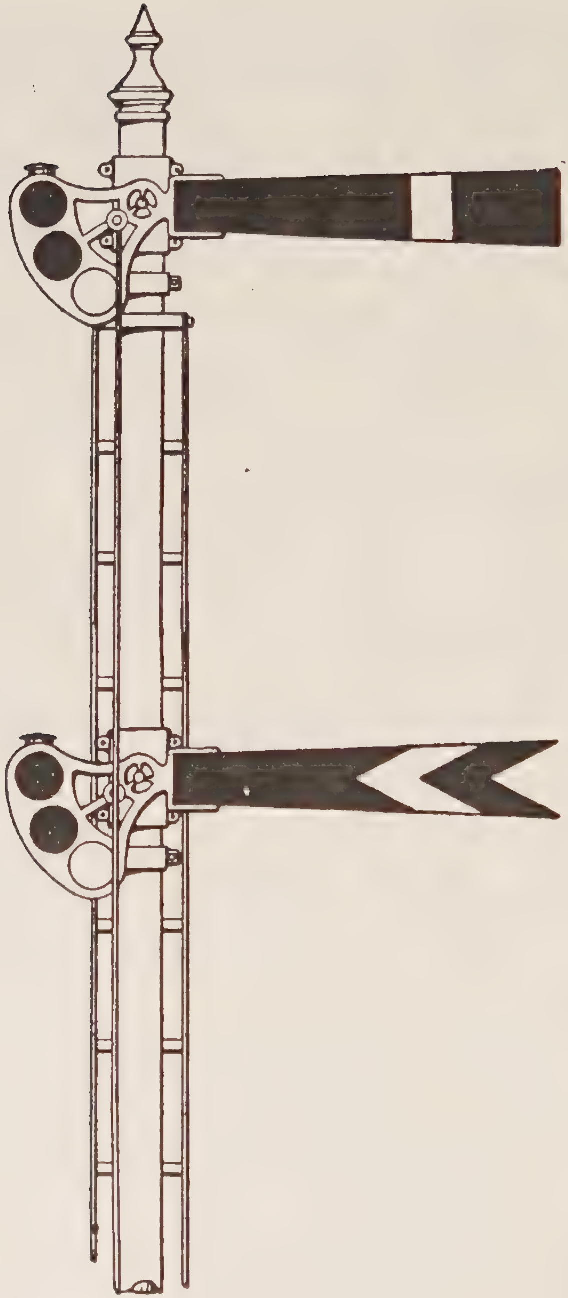


Fig. 130.

blocks at a time, and the middle signal would be of no advantage—merely a useless expense.

Away from terminals, blocks in automatic block territory, are most often from one mile to two miles in length. It is the common practice to have the signal governing the entrance to a block give a caution indication if the second block is not clear. That is, if there are two consecutive blocks, A-B, B-C, if the block B-C is occupied the signal at A would give a caution indication; that is, it would inform an engine runner that it was safe for him to enter the block A-B, but that he must expect to find the block signal at B at stop when he reaches it. This practice does well enough perhaps where blocks are not over a mile long, but it is of very doubtful advantage where they are longer than a mile. In the latter case it is much better, although it costs more, to erect a separate distant signal 2500 feet to 3000 feet from the home block signal.

In early installations of automatic block signals, it

Fig. 131.

was quite often the practice to do without the caution signal, and instead use what is called an "overlap."

By this arrangement a train moving from A to B and from B to C would hold the signal at A at danger behind it until it had reached a point half a mile or so beyond B. In other words until it was half a mile beyond the signal at B so as to have that much protection from that signal, it would not release the signal at A.

This practice as it tends to weaken confidence in the

indication given by the stop signal is not to be recommended.

Until comparatively recently the caution signal, where it was used, was given by a caution signal blade below the home signal blade, as shown in Fig. 130.

The three position signal was designed in order to make one blade give both the clear and the caution indication. Fig. 131 illustrates three consecutive blocks in which the first and second, A-B, B-C are clear, but the third one C-D is occupied. Signal at A is at clear, signal at B is at caution, and signal at C is at stop.

Automatic block signals for single track railways are not in general favor with signal engineers, although a great many of them have been installed during the past five years.

A single track automatic installation costs about as much as a double track installation does, and adds little if any protection except for following movements. Trains cannot pass each other on single track lines except where passing tracks are provided. It is, therefore, useless to let a train pass A in the direction of B after another train has already passed B moving towards A, if there is no passing track between A and B. One of the chief arguments in favor of automatic signals is that a great operating expense—the wages paid to manual block operators—may be saved by their use. In actual practice this rarely if ever works out. In the case of a single track railroad, two trains leave the initial stations of a division, say one hundred miles long, at the same time. If there are no operators stationed along this division the dispatcher starts the two trains out with orders showing at what station they must meet and pass. If they each make about the time which the dis-

patcher figured they would make, they can keep this meeting point, but very frequently one train or the other meets with some delay. As there is no means by which the dispatcher can reach the other train it arrives at the meeting point and waits there, maybe hours, for that which has been delayed, the train and engine men making overtime and traffic being delayed. If on the other hand there are operators all along the line the dispatcher can reach either or both of the trains and change the meeting point whenever it becomes desirable to do so. I have known several cases where automatic signals were put in and operators discharged, who in a month or two had to be re-employed in order to keep the business moving at all satisfactorily.

With all automatic signal installations, as there is a chance of a failure of apparatus causing the signal to stand at stop until repairs have been made, it is customary to allow engine runners to pass the signal at the stop position, after stopping and waiting a limit of time laid down in the rules of the railroad to whom the signals belong. Formerly this time limit was from three to five minutes. The tendency now-a-days is to allow an engine runner to proceed at once after coming to a full stop, which usually means a stop of a minute, allowing for the releasing of the air brakes. After starting up again the engine runner is instructed by the rule to proceed cautiously, prepared to stop within his range of vision until the next signal is reached. If that is at clear he may proceed at regular speed, but if that signal is displayed at danger he must again stop, and after starting up proceed cautiously as before, and continue so to do until he reaches a clear signal or finds an obstruction in the block.

Normal danger automatic block signals stand

normally at danger, as the appellation signifies, and go to clear as a train approaches them, if the block which they govern is clear.

Normal clear automatic block signals stand normally at clear and go to danger after a train or part of it has passed them, remaining so as long as the train remains in the block which they govern. After the train has passed out of the block they return to the clear position.

The most common practice is to arrange the signals, either normal clear or normal danger, to take the danger position after the front truck of the train has passed them from fifty to one hundred and fifty feet.

As before stated, automatic electric signals are arranged to be operated by a ten volt motor. When no current is flowing through the motor the signal is at stop. When a current is allowed to pass through the motor it (the motor) revolves and either pulls or pushes the signal blade to clear. The current for the motor is supplied by a so-called "local battery"—16 cells—placed near the signal. Lalande battery is usually used for this purpose as it is not affected by low temperatures.

A year or two ago there was quite an agitation amongst signal engineers in favor of using storage batteries for this purpose, and several railroads spent a good deal of money providing for their use. One method was to have charging plants at regular intervals along the line and to carry current for charging from them to the batteries which were placed at or near the signals. Another method was to have portable storage batteries which could be shipped in to a central charging station where they would be charged and sent out again to the point where they were to be used. This meant a number of duplicate batteries, of course. From the

fact that the use of storage batteries for this purpose is not being advocated as much as it was the inference is that experiments along this line have not proven as satisfactory as was at first hoped.

A wire leading from the motor is attached to the hinge of the track relay and another wire is

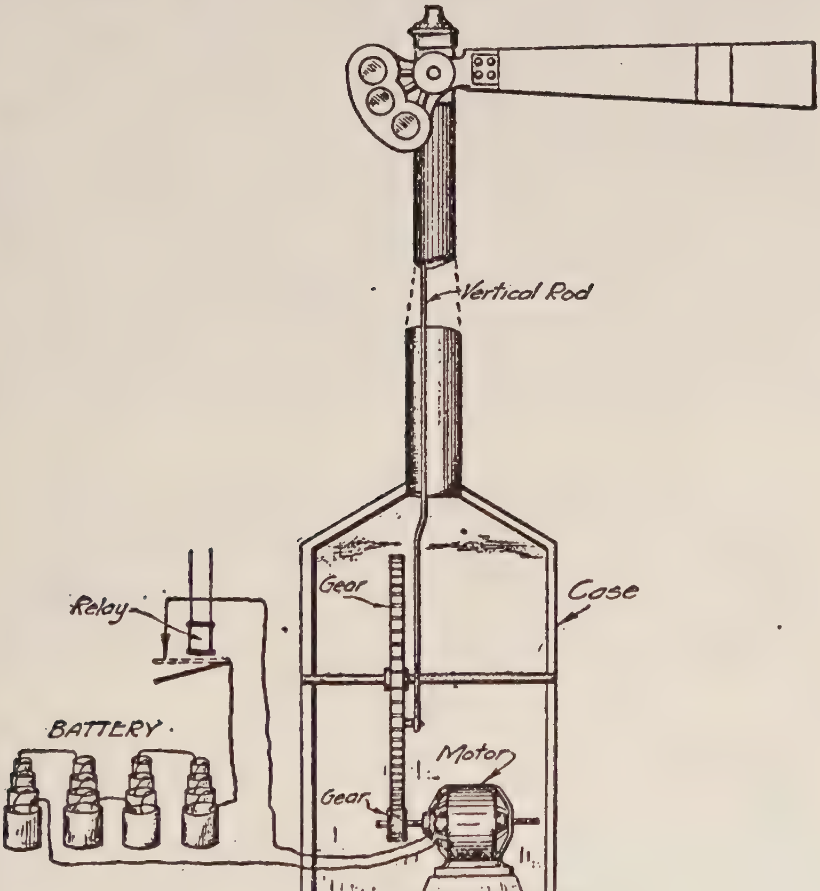


Fig. 132.

attached to either its front or back contact point, from there to one pole of the battery and another wire is run from the other pole of the battery to the other side of the motor. If the front contact is used this circuit is closed when the relay is picked

up and the motor is energised and holds the signal blade at clear. When the relay is down this circuit is broken, the motor is de-energised and the signal blade goes to stop by gravity.

If the back contact is used the reverse is the case.

The cases where the front or back contact is used will be explained later.

Fig. 132 shows a typical arrangement of relay, local battery and signal motor.

We now come to the practical application of the foregoing to a normal danger signal system.

In the first place it should be noted that where blocks are, say two miles long and where ballast conditions are such that short sections are necessary, an arrangement must be made by which the sections may be coupled together so that several

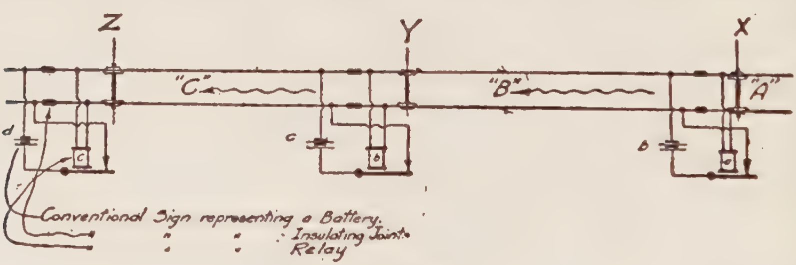


Fig. 133.

of them act as a unit. Fig. 133 illustrates how this is done.

The track battery circuit of the second section shown as section B is looped through the hinge and front contact of the relay of section A so that when a train enters section A, moving in the direction of the arrow, relay (a) drops, breaking the circuit of battery b so that relay b is de-energised and drops also. As the same thing applies to section C its relay drops too, and so on ad infinitum for as many sections as there may be

in the block. In this way a train entering a block drops all the relays ahead of it and keeps them down, but the relay of each section picks up again as soon as the last pair of wheels passes out of that section. For instance, see Fig. 133, with the last pair of wheels at X, relays a, b and c are down. With the last pair of wheels at Y, relay a has picked up again but relays b and c are down; with the last pair of wheels at Z, relays a and b are picked up and relay c is down. When the last pair of wheels has passed out of section C all three relays are picked up again.

Now take Fig. 134. The first section is what is known as a preliminary or clearing section, at the end of this is the signal. Note that the wire a a a connects the signal motor with one pole of

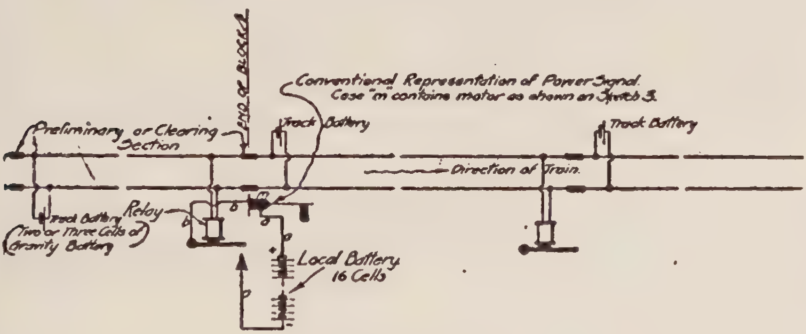


Fig. 134.

the local battery and the other pole of the local battery with the back contact of the relay of the preliminary section. Another wire b b connects the hinge of the relay lever with the other side of the signal motor.

Now it is plain that when the relay is picked up the circuit through the signal motor is broken at the back contact of the relay, but let a train enter the preliminary section the relay drops, clos-

ing this circuit so that the current flows from the local battery through wire a a a through the motor and back through wire b b and the back contact of the relay to the battery. This starts the motor going and pulls or pushes the signal blade to clear. As soon as the last pair of wheels has passed out of the preliminary section the relay picks up again, and the signal goes to danger because the current through the motor is broken at the back contact. So far so good, but as far as we have now gotten there is nothing to prevent the signal clearing again if another train comes into the preliminary section, even if the first train has only gone a few feet beyond the signal.

To insure that the signal remains at danger as

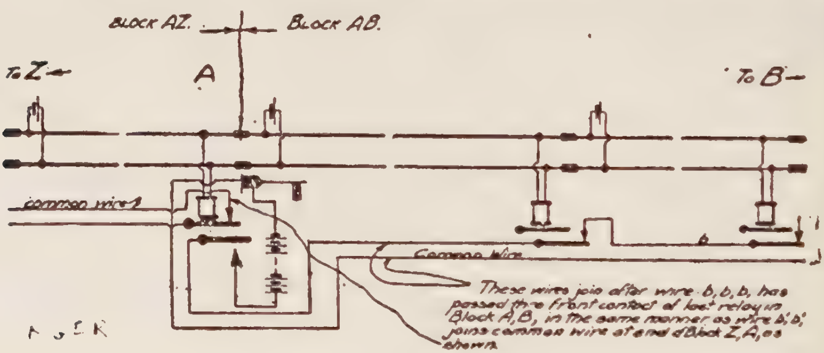


Fig. 135.

long as the first train is in the block the wire b b in Fig. 134 is carried completely through the block as shown in Fig. 135, and is looped through the front contact of the last relay in that block. The wire is usually carried on the telegraph poles and is looped down from the pole to the relay box. In some installations it is looped through every relay in the block so that if any accident should hold the last relay up the line would be broken by one of the others, but the more general practice now-a-

days is to loop it through the last one only, this being more economical, as the leads down from the pole line have to be rubber covered copper wire, carried in trunking, and cost from $75 to $125 each.

Now, therefore, when the train has passed the signal and into the block which that signal governs it must, as before described, have at least one of the relays in that block down, thus breaking the line wire and preventing any current from flowing through the signal motor. The signal consequently stays at danger, even if another train comes into the preliminary section and drops its relay.

The relays are constructed with as many as four separate levers attached to the armature, so that one relay will perform more than one function.

For instance, in a series of blocks the relay of the section at the far end of one block, breaks the line wire for the signal behind it with one of its front contacts, and at the same time acts as the relay for the preliminary section of the signal ahead with one of its back contacts.

This also is shown in Fig. 135.

It is sometimes customary to have the motor circuit of the signal in advance carried on a line wire to the first relay in the block ahead, as shown in Fig. 137, and looped through its back contact so that the signal works off the first relay instead of the last and begins to clear as soon as a train enters the block in advance if no train is to be protected by this signal. This is a mere matter of taste, and does not affect the principle involved, and is done on account of the distant signals when carried on each pole or on separate poles for the home signals ahead.

Where distant signals are used, the object to be gained is to have the distant signal go to clear before an approaching train reaches it if the first

and second blocks in advance are clear, and to stay at caution if either of them is occupied.

This is done as shown in Fig. 136 by having a line circuit from the local battery of the distant signal to the front contact of the last relay in both the first and second block ahead, and through the back contact of the relay in the preliminary section shown as P in the figure.

Now if there is a train in either block A or block B, relay A or relay B is down and the distant signal circuit is broken; but if both these blocks are clear so that the relays are up, the distant signal circuit will be closed when the train enters the preliminary section P, through the back contact of that relay and the distant signal will consequently clear.

The arrangement of the track circuit for normal clear automatic block signals is the same as that

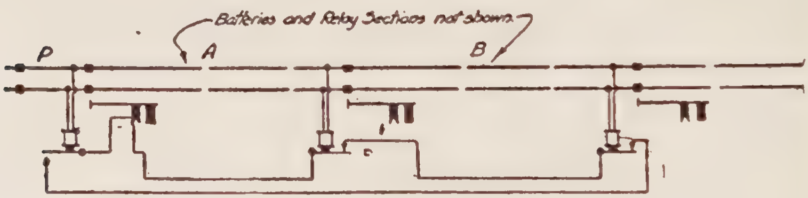


Fig. 136.

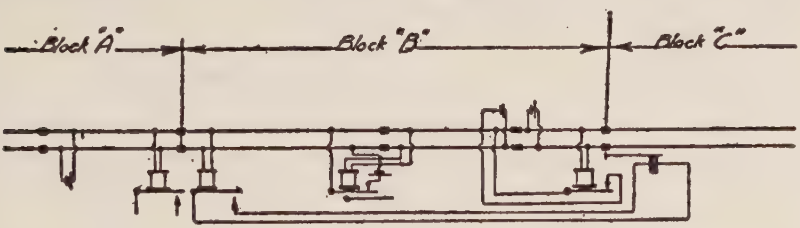
for normal danger, except that there is no preliminary section.

The relays are so arranged that they drop as the train enters the section they govern, and stay down until the train is out of the block. The relay of the first section controls the signal.

Distant signals are sometimes operated by line circuits, as shown in Fig. 136, and sometimes by the use of so-called polarized relays. It is a fact that if a permanent magnet is used for the core of an electro magnet, it will fail to attract its armature if

the current is sent through the coil of the magnet in one direction, while if the current flows in the other direction the core becomes a good magnet. A polarized relay is one with a permanent magnet for the core. By attaching a pole changer to the blades of the home signal, which the distant signal repeats, and also to the home signal blade on the same mast, with the distant signal blade if it is so arranged, the direction of the flow of the current from the track battery may be reversed when either home signal is at stop from what it is when they are at proceed.

By working the distant signal off the front contact of a polarized relay arranged so that it drops when the current is flowing through it in the direction in which it flows when the home signal blades are at stop the distant signals will be at caution whenever the home signals are at stop whether there is a train between them or not. The action of the polarized re-



Note:
Here the arrangement of Relays and Track Batteries is the reverse of that shown in Sketch 24. The Relays drop as Train enters their Section and do not pick up again until last Relay in Block picks up.

Fig. 137.

lay with a train in the section it governs is just the same as that of a neutral relay, (the ordinary relays are called neutral relays) as the current is practically cut off from it entirely then.

Fig. 138 illustrates a distant signal operated through a polarized track relay.

This arrangement saves a great deal of line wire.

In the foregoing I have endeavored to describe

clearly, and in such a manner that a person who has not been actually engaged in the construction and operation of automatic signals and their dependent apparatus, will be able to understand, the primary principles on which these devices operate.

There are, of course, many side issues, such as switch indicators, annunciators, semi-automatic control of manual signals at interlocking plants, etc., which are outside of the elementary principles which I have taken as my text. There is room for a great amount of ingenuity in arranging the circuits so that one set of wires will do for several of them and so that one relay and its shelter will be available for

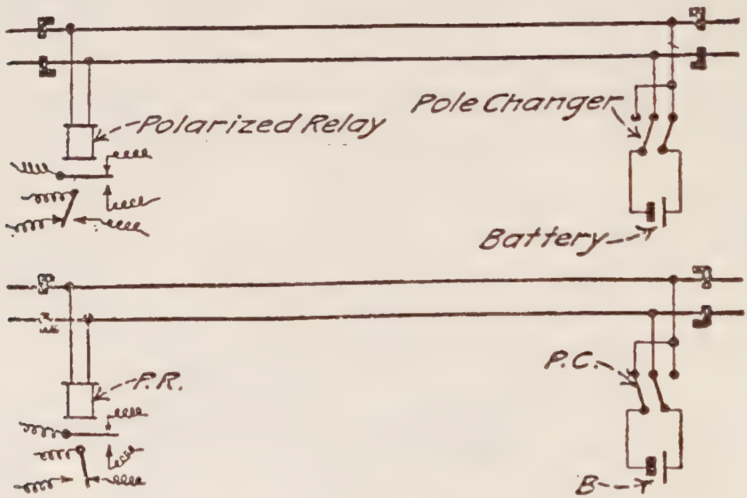


Fig. 138.

several different uses, all in the interests of economy, but to prolong this chapter along such lines would hardly be of advantage in an elementary treatise.

Switch indicators are devices generally made in the form of a dial on which is displayed a miniature semaphore. These are put up at main line switches. When there is no train in the block, the miniature semaphore shows clear. When there is a train in the

block, it shows danger. Their object is to warn trainmen of trains which may be in to clear on a side track not to open the switch and come out on the main track when a train is approaching.

Annunciators are devices sometimes taking the form of bells or buzzers, and sometimes discs or miniature semaphores placed where a block operator or leverman can hear or see them to warn him of the approach of trains. They are generally operated by a local battery, circuit from which is carried through the back contact of the track relay of a section some distance away. As a train enters this section the relay drops, thereby closing the circuit through the annunciator.

Where an interlocking plant is situated in automatic

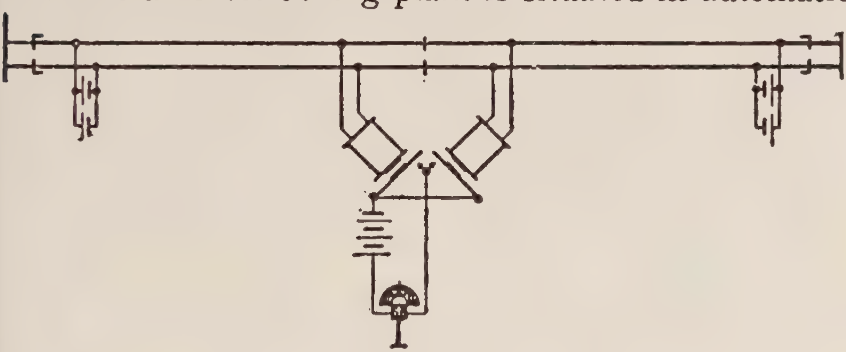


Fig. 139.

block signal territory, it is not uncommon to equip the signals with electric slots so that passing trains set them at danger. This is called semi-automatic control.

Highway crossing alarm bells too, may properly be considered under the head of automatic signals. By far the best practice with these is to use an interlocking track relay placed at the highway crossing, the local circuit for the bell passing through its back contact. Fig. 139 illustrates such an arrangement.

A train moving from left to right drops the left side of the relay, closing the bell circuit and starting the

bell to ringing. As the engine crosses the highway it drops the other side of the relay, which on account of the interlocking feature already described cannot make its back contact and also holds up the armature of the first side enough to break its back contact as well, thus breaking the local circuit and stopping the bell's ringing. In this way nothing but an approaching train will ring the bell.

Within the last year or two in the vicinity of New York City, some automatic signal installations have been made in which the apparatus was designed to operate by an alternating current of high pressure. installations are as yet much in the nature of experiments and as a detailed description of the apparatus used would carry us far into the study of electrical engineering, we will make no further mention of alternating current apparatus.

For a long time almost all the line wire for automatic block signals was insulated, what is known to the trade as "weather proof" wire being used. This wire is covered with a cotton tape dipped in some composition to harden it.

The tendency now is to use more bare wire. Where it is well strung so that the wires cannot touch each other and form crosses, it is probable for all practical purposes that bare wire is just as good as insulated for power distant signals, and automatic block signals as well. There is, of course, some danger from crosses, but it is very doubtful if after a year or two the use of weather proof wire does a great deal to prevent this.

Before leaving the subject of automatic signals, a word or two on the subject of automatic train stops may not be amiss.

There are no regular surface steam railroads where automatic stops are in actual use, but such a public clamor for increased safeguards was raised a year or

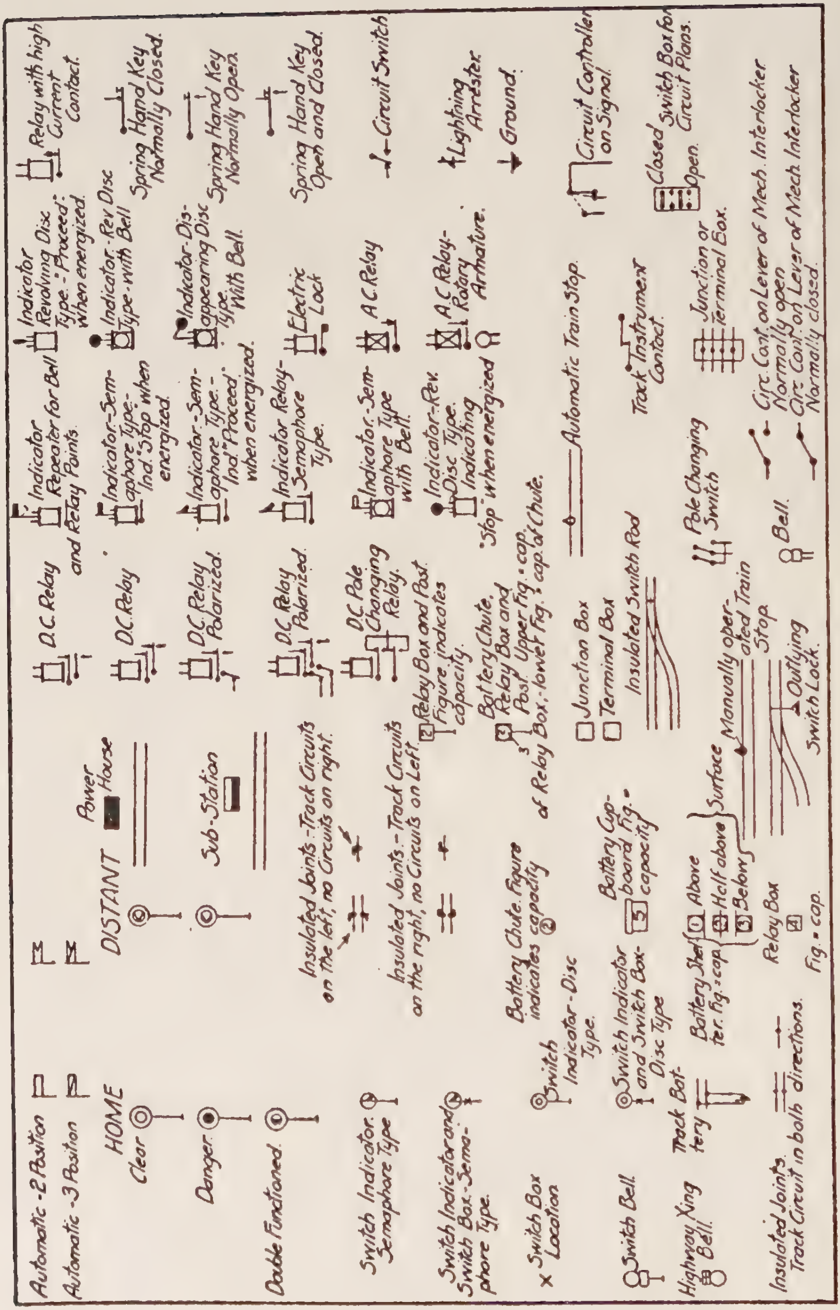
two since, because of several fatal collisions having happened in territory protected by automatic signals, that Congress appropriated $50,000 to enable the Interstate Commerce Commission to investigate this subject. Automatic stops are in use on several elevated railroads and in the New York subway.

The Interstate Commerce Commission appointed a special committee, consisting of four gentlemen well known to be interested in and well informed on signal matters. This committee called on manufacturers and inventors to submit plans of automatic train stopping devices. Those who presented such of these plans as conformed to certain specifications laid down by the committee, were invited to install working models for several months' actual service test.

The tests have only recently been closed, and the committee's report, if yet presented to the Interstate Commerce Commission, has not been made public, so that it would not be fitting here to express an opinion one way or the other as to the merits of any particular device of this sort, or of the practical utility of the principle they embody.

Let it suffice here to say that all such devices are intended by some mechanical means to apply the air brakes to a train which has over-run a stop signal. On some elevated railroads they are used in lieu of derails, and are operated by levermen through the medium of mechanical or power interlocking levers.

As is generally known the air brakes used on railroads are so arranged that an opening made in the train pipe which will allow the compressed air contained therein to escape into the outside atmosphere, applies the brakes to the entire train. By providing some sort of a cock or valve in the train pipe, which will be opened on coming in contact with a trigger situated in the roadbed and working in conjunction with a signal, the arrangement is complete.



Automatic - 2 Position
Automatic - 3 Position
HOME
Clear
Danger
Double Functioned
DISTANT
Power House
Sub-Station
Switch Indicator. Semaphore Type
Switch Indicator and Switch Box - Semaphore Type.
Switch Box Location
Switch Bell
Highway Xing Bell.
Insulated Joints. Track Circuit in both directions.
Switch Indicator - Disc Type.
Switch Indicator and Switch Box - Disc Type
Track Battery
Insulated Joints: - Track Circuits on the left, no Circuits on right.
Insulated Joints: - Track Circuits on the right, no Circuits on Left.
Battery Chute. Figure indicates capacity
Battery Cupboard. Fig. = capacity
Battery Shelter. Fig. = cap.
Above
Half above
Below
Surface
Relay Box
Fig. = cap.
Relay Box and Post. Figure indicates capacity.
Battery Chute, Relay Box and Post. Upper fig. = cap. of Relay Box; lower fig. = cap. of Chute.
Junction Box
Terminal Box
Insulated Switch Rod
Manually operated Train Stop
Outlying Switch Lock.
D.C. Relay
D.C. Relay
D.C. Relay Polarized.
D.C. Relay Polarized.
D.C. Pole Changing Relay.
Automatic Train Stop.
Pole Changing Switch
Bell.
Indicator Repeater for Bell and Relay Points.
Indicator - Semaphore Type: - Ind. "Stop" when energized.
Indicator - Semaphore Type: - Ind. "Proceed" when energized.
Indicator Relay - Semaphore Type.
Indicator - Semaphore Type with Bell.
Indicator - Rev. Disc Type: Indicating "Stop" when energized
Track Instrument Contact.
Circ. Cont. on Lever of Mech. Interlocker Normally open
Circ. Cont. on Lever of Mech. Interlocker Normally closed.
Indicator Revolving Disc Type: "Proceed" when energized.
Indicator: Rev. Disc Type - with Bell
Indicator - Disappearing Disc Type. With Bell.
Electric Lock
A.C. Relay
A.C. Relay - Rotary Armature.
Junction or Terminal Box.
Relay with high Current Contact.
Spring Hand Key Normally Closed.
Spring Hand Key Normally Open.
Spring Hand Key Open and Closed.
Circuit Switch
Lightning Arrester.
Ground.
Circuit Controller on Signal.
Closed
Open.
Switch Box for Circuit Plans.

Fig. 140.

Where used in connection with automatic block signals, a great many conditions must be fulfilled by the apparatus. For instance, the trigger must be in the position to apply the brakes to an oncoming train so long as anything remains in the block, or so long as there is a misplaced switch or a broken rail therein. This necessitates the use of a track circuit.

The committee's report will in all likelihood be made public with the next report of the Interstate Commerce Commission, and we will then be in a much better position to discuss this branch of signalling.

Fig. 140 gives a list of conventional signs used on plans showing automatic signal installations.

CHAPTER XX.

JOINT WORK—CONTRACTS—PUBLIC AUTHORITIES—ESTIMATES.

As a great many interlocking plants are built to protect crossings of the lines of two or more different railroads, and as frequently they are owned jointly by the several companies interested, the duties of the signal engineer require that he should frequently work in conjunction with signal engineers of other railroads. It is the well nigh universal practice that where two or more companies are part owners in an interlocking plant, one or the other of them maintains and operates it, and renders monthly bills against the other interested company or companies for a certain proportion of the expense of such maintenance and operation.

The maintenance of an interlocking plant is considered as being that expense which would be necessary to keep the plant in good working order if the levermen were removed and the plant was to be operated by the trainmen of each road.

The operation is that expense which would be incurred over and above the maintenance while levermen were permanently stationed at the plant.

Repairmen's labor, repair parts, paint, illuminating oil for signals and lubricating oil are the principle items which go to make up the charge for maintenance.

Levermen's wages, fuel, stationery, illuminating oil for tower and battery supplies are those which go to make up the charge for operation.

Where a joint plant is to be built a written agreement is generally signed by the interested companies which defines the rights and obligations of each with relation to the plant, and specifies the proportion of the cost of maintenance and operation each is to pay.

Until a comparatively recent date there was no uniformity whatever in the form of these agreements or contracts, and no rule by which either company's proportion of the expense could be computed. Sometimes a purely arbitrary division of the expense was made; at other times the number of trains passing through the interlocking plant on the line of each company during a given time was used as a basis, and again the number of levers in the service of each company.

This latter was probably the more equitable method, but it led to a great deal of useless quibbling amongst signal engineers, each trying to arrange the interlocking in his line so as to use as few levers as possible, and the introduction of power interlocking, wherein a great many signals are selected and operated by one lever made a lever division difficult to agree upon.

The Railway Signal Association has, however, suggested a method which is now quite generally accepted, of dividing each plant into a number of operated units, or functions, and having each company assume that proportion of the expense of maintenance which is represented by the ratio of the number of units in its track to the total number of units in the plant.

The operation, too, is frequently, though not al-

ways, divided on the same basis as the maintenance.

One huge advantage of a division on the unit basis is that it carries with it a redivision at all times in case of enlargements or additions to a plant being made after it has once been put in service.

It is sometimes argued that the unit basis is not an altogether fair one because it quite frequently occurs that some of the units in the track of one company are used very little, while all of those in the track of some other company are in constant use, and consequently require more attention and repair.

Although this is no doubt true to a certain extent, it is almost certain to be the case at some other plant operated jointly by the same companies that the conditions will be reversed, so that the matter works out to be as broad as it is long, and the unit basis has so many advantages, is so elastic and is so surely as equitable as anything yet suggested, that those companies which have not already done so cannot be urged too strongly to accept it at once.

The table of operated units as recommended by the Railway Signal Association is as follows:

Table of Operated Units.

Name of Operated Unit.	Value.
Each signal arm working in two or three positions	1 unit
Each power signal arm working in two or three positions on mechanical plants, normal indication locking included	2 units
Each pair of switch points	1 unit

Each single slip switch (2 pairs of switch points) ....2 units
Each double slip switch (4 pairs of switch points) ....4 units
Each set of movable point frogs (2 pairs of frog points) ....2 units
Each derail ....1 unit
Each 55 feet of detector bar with or without locks ....1 unit
Each torpedo placer.................................1 unit
Each drawbridge coupler............................1 unit
Each drawbridge rail surface and alignment lock for one pair of rails.......................1 unit
Each drawbridge leveling and operating apparatus lock ....1 unit
Each track circuit ....1 unit

The signal engineer must, of course, be frequently consulted in the drawing up of agreements, with regard to interlocking plants at new crossings, or at old crossings where no interlocking plants have heretofore existed.

All such cases may be roughly classed under two general heads:

(1) Cases where it is to the mutual advantage of each company to install the interlocking, and where each intends to assume a proportion of the expense thereof.

(2) Cases where one company, whose line is already built, proposes to allow another company to cross it at grade, but in consideration of the fact that it has prior rights, is to bear no proportion of the expense of the interlocking, the junior company bearing it all.

A Committee of the Railway Signal Association, in the interest of uniform practice, has proposed

the following as a form of contract to be used in cases coming under the first head.

THIS AGREEMENT, made and entered into this......day of......A. D. by and between the A and B Company, hereinafter called the X Company, party of the first part, and the C and D Company, hereinafter called the Y Company, party of the second part.

Witnesseth:

Whereas, the roads of the respective parties now intersect and cross each other at........, as provided for in an agreement made and entered into the......day of......A. D., by and between the E and F Company, of the first part, and the G and H Company, of the second part, of which the said X Company and said Y Company are the respective successors, and,

Whereas, the parties are mutually desirous of erecting, renewing, maintaining and operating an interlocking plant at said crossing to facilitate and render more safe the passage of trains over the same, the location of said crossing being identified, and the said interlocking plant to be arranged as shown upon blueprint dated........, identified by the signature of the........engineer of the first party, and the........engineer of the second party, attached hereto, marked Exhibit "A," and hereby made a part of this agreement, and

Whereas, the parties hereto have agreed upon the terms and conditions upon which said interlocking plant, as shown by said Exhibit "A," shall be constructed, renewed, maintained and operated;

Now therefore, in consideration of the premises, and in further consideration of the mutual covenants and agreements hereinafter stipulated to be kept and performed, it is agreed between the parties for

the purpose of defining the terms and conditions upon which said interlocking plant shall be constructed, renewed, maintained and operated, as follows:

First—The said X Company agrees to construct an interlocking plant as shown upon said Exhibit "A," and in accordance with the specifications to be approved by the above named engineers, under the operation of which trains of either party may, pursuant to the laws of the state of........, pass over the tracks of the other party, without coming to a stop. The cost of removing any existing safety devices or appliances shall be divided in like manner as the cost of the former renewal and maintenance expense of said devices or appliances has been heretofore divided.

Second—The cost of constructing, renewing and maintaining said interlocking plant, as shown upon said Exhibit "A," shall be borne on an operated unit basis by the parties hereto, in the proportion that the total number of operated units used to interlock the tracks of each of the respective parties bears to the total number of operated units of the complete interlocking plant, as shown by the table of operated units on said Exhibit "A."

Third—(a) The cost of operating said interlocking plant, as shown by said Exhibit "A," shall be borne equally by the parties hereto.

(b) The cost of operating said interlocking plant shall be borne as follows:

Said .... Company shall pay the sum of .... dollars ($......) per month, the amount which it now pays for railway crossing watchmen, their supplies, and maintenance of railway crossing

Note—(a) and (b) to be used as circumstances require.

gates; the balance of said operating expenses shall be divided equally between the parties hereto.

Note. (a) and (b) to be used as circumstances require.

Fourth—All extensions or changes of said interlocking plant arising from changes made in any existing track or tracks, or made to cover any future track or tracks or connections which either party may have the right to construct, or which may be required by reason of any changes made in the standard appliances of either Company, or ordered by proper authority, shall be made by said X Company, and the first cost of such extensions or changes shall be borne by the party hereto for whose benefit said extensions or changes are made, and the amount chargeable for renewal and maintenance to each party in such case is to be determined by the proportion which the total number of operated units then used to interlock the tracks of each of the respective parties, bears to the total number of operated units of the complete interlocking plant.

Fifth—The renewal and maintenance of said interlocking plant shall be under the sole charge and control of said X Company, and it shall employ competent persons to renew and maintain the same, and such parties from time to time so employed shall be considered as joint employes of the parties hereto, and shall be removed for good and sufficient reasons upon request in writing of the general managing officer of the said Y Company.

And it is further mutually agreed and understood that in event said Y Company shall in writing notify said X Company of renewals and repairs that may be necessary for the safe and proper operation of the said interlocking plant, and if said X Company neglects for a period of 30 days to make said necessary renewals and repairs, then said Y Company shall have the right to make such renewals and

repairs, and said X Company, upon presentation of the proper bills therefor, will pay its proportion of the amount so expended.

Sixth—The operation of said interlocking plant shall be under the sole charge and control of said X Company, and it shall employ competent persons to operate the same, and such persons from time to time so employed shall be considered as joint employes of the parties hereto, and shall be removed for good and sufficient reasons upon request in writing of the general managing officer of the said Y Company; and it is further mutually understood that either Company may use the signalmen in its telegraph or telephone service, but in event additional expense is so incurred on account of increased wages of operators over levermen, the Company using the operators in its service shall bear the additional expense.

Seventh—The salaries of employes connected with maintenance, renewal and operation of the interlocking plant shall be the same as the standard salaries paid by the X Company for similar service to its other employes in the territory of the said X Company's .... Division.

Eighth—The payment of all bills under this agreement shall be made not later than the twenty-fifth day of the month following the month in which said bills are rendered. The bill for expense of construction shall be made as a final bill, unless otherwise mutually agreed and understood. In the event that partial bills for expense of construction are rendered, each such partial bill shall not only show fully the part of the construction expense to be paid by such bill, but shall also include a statement of all construction expense which has been covered by any partial bills which may have been rendered and paid previously.

Ninth—In making bills for the cost and expense of constructing, renewing and maintaining said interlocking plant, all labor and material shall be charged for at actual cost, plus .... per cent added to material and .... per cent to labor for handling superintendence, use of tools and accounting.

The labor for the operation of said plant shall be charged for at its actual cost, without the addition of any percentage.

Tenth—Each of the parties hereto will, without cost to the other, furnish and install its own derails, switch rods, special switch and derail timbers, insulated track joints, crossarms, pins and insulators, and will renew and maintain them from time to time thereafter; likewise, without cost to the other party, do all the track work and grading along its own tracks necessary to prepare the same for the installation of said interlocking plant, and will also provide and maintain proper drainage upon its right of way.

Eleventh—Each of the parties hereto will, at its own expense, keep all switches and derails in its own tracks free from ice, snow, dirt or other obstructions which may interfere in any way with the proper working of said interlocking plant, and in case either party fails so to do, the other party shall have the right to enter upon the premises of the party at fault and remove such ice, snow, dirt or other obstructions, in which event the party at fault shall reimburse the party doing such work for all expense thereby incurred, plus .... per cent to cover superintendence, use of tools and accounting.

Twelfth—Each party hereto shall pay for all loss, damage and expense caused by its separate agents or employes, either to the interlocking plant, to

the property of the other party or to others not parties to this agreement.

All loss, damage and expense caused by the individual negligence of employes connected with the construction, renewal, maintenance or operation of the interlocking plant, or by the combined negligence of such parties hereto, or by failure of any part of the interlocking plant, shall be borne and paid for by the party hereto that may be using the interlocking plant at the time such loss, damage and expense occurs, and, if same shall occur while the trains of both of the parties hereto are at the crossing, or shall be caused by the combined negligence of the separate employes of the parties hereto, each party therein involved shall bear and pay for all loss, damage and expense caused to its own property, or to persons or property in its charge; all other loss, damage and expense caused as above shall be borne and paid for equally by the parties therein involved.

Thirteenth—It is further distinctly understood and agreed that any and all agreements relative to said crossing existing between the parties hereto, or their predecessors, so far as they conflict, or are inconsistent with the terms and provisions of this agreement, are hereby annulled, but in all other respects shall continue in force and virtue.

Fourteenth—Should any dispute arise between the parties to this agreement concerning obligations or rights of either of them hereunder, the same shall be referred to a board of three arbitrators, one to be chosen by each party hereto and the third by the two so chosen. If either party shall fail to appoint its arbitrator within fifteen (15) days after the party desiring arbitration has appointed its arbitrator, and given written notice to the other

of such appointment and of the matter proposed to be arbitrated, then the arbitrator so appointed shall appoint an arbitrator for the defaulting party, and the two so appointed shall appoint the third to complete the board as above provided, and said board so appointed shall hear and decide the dispute and assess the expenses of arbitration. The decision of said arbitrators chosen in either of said ways, or that of a majority of them, shall be final and conclusive between the parties upon the matters concerning which arbitration was demanded.

Fifteenth—The provisions of this agreement shall be binding upon and inure to the benefit of the parties hereto, their successors, lessees and assigns.

In testimony whereof the parties have caused these presents to be executed in duplicate by their respective proper officers as of the day and year first above written.

The A. & B. R. R. Co.

Attest: By ....

....

Secretary.

Seal.

The C. & D. R. R. Co.,

Attest: By ....

....

Secretary.

Seal.

The same Committee is understood to be engaged upon a similar form to cover cases coming under the second head, but as its recommendation has not yet been made public, I shall offer the following, which my experience has shown to be a very serviceable form.

THIS INDENTURE, made this ...... day of ...... A. D. ......, by and between the A. B. & C. Railway Company, hereinafter styled the C. Company, and the E. F. & G. Railway Company, hereinafter styled the G. Company.

Witnesseth.

That the C. Company, in consideration of the sum of One Dollar to it paid by the G. Company, the receipt whereof is hereby acknowledged, and in further consideration of the faithful performance by the G. Company of all its agreements herein contained, hath granted and by these presents doth grant unto said G. Company upon the several conditions hereinafter set forth, the right to lay down, maintain and operate a single track railway of standard gauge over and across the right of way and existing main track of the .... Division of the railway of the C. Company, chiefly in the ...... half of the .... quarter of section.........., in Township .... of Range ...., in .... County, ..., so that the center lines of the tracks of the respective parties hereto shall intersect at the point designated by "A" upon the identified plat hereto attached and made part hereof, and at the angle of ...... degrees and .... minutes upon said plat represented.

Subject always to the observance and performance by the G. Company of all and singular the following conditions, covenants and agreements to be by it observed, kept and performed, to-wit;

First. It is a condition of the aforesaid grant, and the G. Company agrees, that notwithstanding said grant, the C. Company shall have the right to retain the tracks now owned and operated by it at

the place of crossing aforesaid, and may at any and all times hereafter there lay down, maintain and operate such other and further tracks as it may deem necessary, and that the G. Company shall not and will not at any time or in any manner impair the usefulness of any of the aforesaid tracks, whether now or hereafter constructed.

Second. It is a further condition of the aforesaid grant that the G. Company shall, and said Company also covenants and agrees that it will, whenever thereto notified by the Chief Engineer of the C. company, furnish and put in place at its own expense, and in strict conformity to the plans, specifications and directions of said Chief Engineer, all such crossing frogs, movable points, crossing signals, gates, targets and other appliances, as said Chief Engineer shall at any time require for making and protecting all crossings, present or future, of the C. Company's tracks now or hereafter constructed at or near the point aforesaid; and that it shall and will at its own expense in like manner forever maintain, repair and renew all such frogs, signals, gates, targets and other appliances, and shall and will pay all the wages of such flagmen as the C. Company may be required by law or ordinance, or as its managing officer may deem necessary, to employ in operating said signals and gates, and the cost of all supplies required in such operation.

Third. It is a further condition of the aforesaid grant that the G. Company shall, and said Company also covenants and agrees that it will, at its own expense, forever maintain and keep in good repair, the substructure, roadbed, and ties at the crossing aforesaid, and will keep all the frogs, guard rails and switches thereat, and at the junction of the connecting and transfer tracks hereinafter mentioned with the tracks of the C. Company, securely blocked

and protected, so as to make them as free as possible from danger to the employes of the C. Company; and if the G. Company shall neglect or fail to perform promptly and strictly any of its covenants contained in this or in the next preceding section hereof, then and in every case the C. Company may construct, repair or renew, as the case may require, any of the crossings or appurtenances in said sections mentioned, and the G. Company shall and will promptly repay to the C. Company the entire cost of all the material furnished and work done by it in such construction, repair or renewal.

Fourth. It is a further condition of the aforesaid grant that the C. Company shall be entitled to, and will, furnish and erect at or suitably near to the place of crossing aforesaid, but wholly at the expense of the G. Company, and in accordance with plans, specifications and requirements of the Chief Engineer of the C. Company, an interlocking and derailing plant, with all such machinery, apparatus and appurtenances (all hereinafter briefly designated as "interlocking plant") as said Engineer may require for the operation thereof, and will connect the same with the tracks of the respective parties hereto; that it will, at like expense of the G. Company, at all times maintain such interlocking plant in proper condition and repair; and shall be entitled, at the like expense of the G. Company, to connect the same with any additional track or tracks which it, the C. Company, may lay across said track of the G. Company at or near said place of crossing; that it will at like expense of the G. Company, furnish the signalmen and all supplies necessary for the operation of such interlocking plant; and that the G. Company shall, and it hereby agrees that it will, repay to the C. Company all the cost of such interlocking plant, and of the installation and original

connection thereof, all the cost of any such additional connections, and all the monthly expenses of the maintenance, repair and operation of said interlocking plant, upon presentation, from time to time, of proper monthly bills of such cost and expenses respectively; the C Company shall and will upon complaint of the G. Company, for reasonable cause stated, remove any agent or servant from service in or about such interlocking plant.

Fifth. It is a further condition of the aforesaid grant, and the G. Company also agrees, that so long as the C. Company shall maintain fences up to the point of intersection of the G. Company's tracks with the respective boundary lines of the C. Company's premises, the G. Company shall and will maintain, in good order, proper cattle guards at the points of intersection aforesaid, to prevent animals from straying upon the C. Company's premises from the track or grounds of the G. Company.

Sixth. And the G. Company further agrees that it will at all times when so required by the Chief Engineer of the C. Company, make the crossing frogs at the crossing aforesaid conform to such changes as the C. Company may make in the section of its rails laid on the approaches thereto; and that if a device be manufactured for the purpose of giving a continuous rail over a crossing on the line having the right of way over the same, it, the G. Company will at its own expense, when thereto requested, put in such device at the above mentioned crossing and connect the same with the interlocking plant aforesaid.

Seventh. It is a further condition of the aforesaid grant, and the G. Company also agrees, that in the passage of trains over the aforesaid crossing, if passenger trains of each party hereto arrive thereat simultaneously, the trains of the C. Com-

pany shall have precedence over the trains of the G. Company; and, in like case, the freight trains of the C. Company shall have precedence over the freight trains of the G. Company; but in every case a passenger train shall have preference over a freight train.

Eighth. It is a further condition of the aforesaid grant that the G. Company shall, and said Company covenants and agrees that it will, pay all the cost of any connecting or transfer track which may be at any time required at the place of crossing aforesaid, whether such track be ordered by competent authority or put in by agreement between the parties hereto.

Ninth. It is a further condition of the aforesaid grant that the G. Company shall, and said Company also covenants and agrees that, anything herein contained to the contrary notwithstanding, it will at all times, and it does hereby, indemnify the C. Company against all loss, cost, damage or expense of any kind which said last named Company may suffer, or for which it may become liable, in consequence of any neglect or failure of said G. Company strictly to keep and perform all its covenants and agreements in this contract contained. And said G. Company further agrees that it will at all times, and it does hereby, assume all risks, loss or damage to its own property, or to property and persons in its employ or care, or resulting from the death of any such person, which shall in any wise arise from the operation of said interlocking plant by employes of the C. Company, and will save said Company harmless from all such loss, risk or damage and from all consequent expense.

Lastly. The grants, covenants and stipulations hereof shall extend to and be binding upon the respective successors and assigns of the parties

hereto; provided, however, that all rights and privileges hereinabove granted shall cease and become void unless the same shall be exercised by the G. Company within on year from the date hereof.

IN WITNESS WHEREOF, the C. Company and the G. Company have caused these presents to be signed by their proper officers, and their corporate seals to be hereto affixed and attested, the day and year first above written.

A. B. & C. Ry. Co.,

Attest: By ....

....

E. F. & G. Ry. Co.,

Attest: By ....

....

Although the form of contract proposed by the committee of the Railway Signal Association does not include it, I have always found it very convenient to insert a clause in a joint expense contract whereby each party agrees to paint its own signal blades and masts from time to time as they shall require painting, free of cost to the other party or parties.

Each company generally has its own standards with which the other companies are not always familiar, and as almost every Railroad Company sends out painters' gangs to paint its station buildings, water tanks, switch target and so forth, each year, it is no real hardship to take charge of its own signals.

Some signal engineers are very arbitrary in their demands to have their own specifications followed to the most minute details, even where some other company maintains a plant in which they are in-

terested. Where the maintaining company is a responsible one, and no company which is not responsible should be allowed to take charge of the maintenance, it is always much better to allow that company to use its own standard material throughout the plant, except, of course, in the case of signals where each company should insist on having its own standard colors and aspects.

The laws of many States require that where there is a grade crossing, a junction or a drawbridge trains must come to a full stop before moving over such dangerous point, unless proper interlocking is provided. Where such laws exist, the Railroad Commissions are given authority to lay down rules for the construction of interlocking plants, and to have inspections made thereof. No railroad being allowed to run its trains over such places at speed until a proper permit is granted by the Railroad Commission to do so.

Sometimes the Railroad Commissioners themselves see to the inspection of new plants, but it is quite frequently the case that the Commission employs a Consulting Engineer to pass upon technical matters of this sort. This latter plan cannot be too highly commended as advantageous to the railroads and to the public as well. In most cases the rules require that a full set of plans consisting of a copy of the track plan showing the signals, switches, derails, etc., a copy of the dog sheet and a copy of the locking sheet shall be filed with the Commission for approval before the work is started. When the work is completed, on proper notification from the railroad company, an inspecting officer visits the plant and if he finds it satisfactory issues a permit.

The duty of providing the necessary plans, meeting the inspecting officer and making any required

revision or alteration in plans or plant, usually falls upon the signal engineer.

For these reasons every signal engineer should make it his business to thoroughly familiarize himself with the laws and regulations of each State through which his railroad passes, so far as these matters go.

It may be called to the reader's attention here that it is a very good plan to show the profile of each of the lines for a couple of miles either side of the crossing or junction, and on either side of the bridge, if a draw bridge, on the track plan. Some Commissions require this and some do not, but it is a good plan to show it anyway.

Of course the signal engineer is frequently called on to furnish estimates of the cost of contemplated work. It would be difficult in a treatise of this nature to lay down any hard and fast figures on the cost of signal work, as the prices of material vary from time to time and the scale of wages paid is not uniform in all sections of the country.

Nevertheless I shall endeavor to give a few rough figures which may help a beginner.

Plain mechanical interlocking, without any accessories may be roughly estimated at $275 per working lever, exclusive of the cost of the tower. The cost of towers for a sixteen-lever machine, which is the minimum size that should be built, varies from $750 to $1,800, according to the method of construction employed by the railroad whose tower it is, and it would be useless, therefore, to give any figures here on cost of towers. For each power distant signal at a mechanical interlocking plant add $275; for each mechanical time lock add $100; for each electric locking circuit add $200, and for each indicator or annunciator add $100. These figures are approximations only, but they

will make an estimate within 15 per cent of the actual cost in most cases.

If a closer estimate, than the above figures would give, is desired, there is nothing to be done but to make out a complete bill of material from the track plan. The signal companies' catalogues give list prices for all material which these companies furnish, and the discounts given, if any, are known to all purchasing agents, so that a very accurate estimate on the cost of material may be made.

As for the labor, an estimate on that is largely a matter of experience and the local scale of wages.

With the scale of wages paid throughout the Mississippi and Missouri valleys plain mechanical interlocking should be put in for $50 per lever labor. This does not include the tower, and it means that the signal men will not be delayed waiting for material or track work, which always adds to the cost.

This will also cover power distant signals and time locks. For electric locking circuits, indicators or annunciators, add $50 each.

As an aid by which any reader who may wish to draw up a bill of material for a mechanical interlocking plant may check himself the following items appear on a complete bill of material for one recently built to protect a crossing having power distant signals on one line, and mechanical distant signals on the other, and several side track switches. All catalogue references are omitted.

INTERLOCKING MACHINE, improved Saxby and Farmer, or Style A. Give number of working levers, number of spare spaces. State how many levers are for pipe and how many for wire connection, and if any levers are to be equipped with electric locks for back locks or route locking, so state, or if time locks are required, so state. Enclose locking sheet or copy of

track plan from which locking sheet may be made with order.

VERTICAL CRANKS, VERTICAL DEFLECTING BARS OR ROCKING SHAFTS, for leadout.

HORIZONTAL DEFLECTING BARS OR BOX CRANKS, for leadout.

HORIZONTAL CRANKS.

COMPENSATORS.

PIPE CARRIERS, giving number required of each different "way."

TRANSVERSE PIPE CARRIERS, 1, 2 and 3 way.

SOLID JAWS, tanged for 1-inch pipe.

SCREW JAWS, tanged for 1-inch pipe.

PIPE LUGS.

POINT ADJUSTING SCREWS.

LAYOUTS FOR SWITCHES. These include detector bars, tie plates, front and lock rods, bolt locks, rail clips, special switch adjustments, facing point locks or switch and lock movements, etc., and are listed assembled in the signal companies' catalogues, so that a great deal of itemization may be saved by ordering them in this way.

Signal companies require that in ordering, the following information be given:

Type of facing point lock or switch and lock movement desired.

Type of front and lock rod.

Type of tie plate.

Type of bolt lock (number of way and whether pipe or wire connected).

Type of detector bar and rail clip, giving size and pattern of rail on which same are to be used.

LAYOUTS FOR DERAILS, giving same information as above.

WIRE CARRIERS.

VERTICAL CHAIN WHEELS, for inside of tower.

BOX CHAIN WHEELS, for leadout.

HORIZONTAL CHAIN WHEELS.

MECHANICAL DISTANT SIGNALS.

POWER DISTANT SIGNALS.

HOME SIGNALS.

DWARF SIGNALS.

RELAY BOXES, for the distant signals (if catalogue reference for signal does not show them).

RELAYS, for power distant signals, 250 to 500 ohm resistance.

RELAYS, for track circuit, 4 ohm. resistance.

BATTERY CHUTES.

RELAYS INTERLOCKING (4 OHM), if required for electric locking.

ELECTRIC LOCKS, if same have not been ordered with the machine.

WIRE EYES.

SPLIT LINKS.

WIRE ADJUSTING SCREWS.

The foregoing covers material manufactured by the Signal Companies and is to be ordered from them. What follows may as well be made in the railroad company's shops or bought of local dealers.

ROUNDELS, red, yellow, green, for arm plates.

ROUNDELS, blue or purple, for back lights.

ONE-FOURTH INCH STRAIGHT LINK CHAIN for chain wheels.

ONE-INCH SIGNAL PIPE PLUGGED AND RIVETTED.

SEMAPHORE LAMPS.

CAST IRON PIERS FOR CRANKS AND COMPENSATORS.

SHORT BOLTS FOR SAME (two to each).

CONCRETE PIPE CARRIER FOUNDATIONS.

HOOK BOLTS FOR SAME (two to each).

TOPS FOR FOUNDATIONS, either metal or 3-inch x 8-inch oak.

Give length, if oak.

LUMBER, one-inch common pine for concrete forms.

CEMENT AND OTHER CONCRETE MATERIAL.

WASHERS.

IRON, ¾-INCH X 2½-INCH, for tie straps around switches.

LAG SCREWS, ¾-INCH X 5-INCH, to fasten down tie straps.

HOOK BOLTS, ONE-INCH DIAMETER, to fasten high signal poles to foundations.

HOOK BOLTS, THREE-QUARTER-INCH DIAMETER, to fasten dwarf signals to foundations.

HOOK BOLTS, ONE-HALF-INCH DIAMETER, to fasten dwarf signal chain wheels to foundations.

MACHINE BOLTS, THREE-QUARTER-INCH DIAMETER, various lengths required.

DERAILS.

OAK TIMBERS, for use as special ties at switches and derails.

RAIL BRACES, to fit on tie plates.

PAINT, for pipe lines.

PAINT, for poles.

PAINT—red, green, yellow—for levers and blades.

OIL, LARD OR VASELINE, for lubricating locking of machine.

OIL, LINSEED, for thinning paint.

OIL, BLACK, for oiling up before plant goes in service and for drilling.

BLACKSMITHS' COAL.

LINE WIRE, for power distant signals.

CROSS ARMS, for carrying line wire on poles.

CROSS ARM BRACES, for carrying line wire on poles.

INSULATORS, for carrying line wire on poles.

CROSS ARM PINS, for carrying line wire on poles.

THROUGH BOLTS, for attaching cross arms to poles.

BATTERY CELLS, Lalande.

BATTERY SHELTERS, to hold local battery at distant signals, unless furnished with the signal.

TRUNKING, 1-inch x 1-inch groove, with capping.

TRUCKING, 1¾-inch x 1¾-inch groove, with capping.

OAK STAKES, 3-inch x 4-inch x 4 feet, for trunking and wire lines to distant signals.

WIRE, No. 12, rubber covered copper, for connections to pole line and inside wiring.

TAPE, adhesive, for wrapping joints.

TAPE, outside, for covering joints.

SOLDER.

SOLDERING FLUX.

NAILS, for nailing trunking to stakes.

NAILS, for nailing capping to trunking.

NAILS, for nailing concrete forms together.

BATTERY CUPBOARD, for battery in tower.

LIGHTNING ARRESTERS.

PORCELAIN CLEATS, for inside wiring.

GROUND RODS, for lightning arrester grounds.

WIRE, No. 9 galvanized steel semaphore, for wire connected signals.

If an estimate on the cost of a power interlocking plant is desired, $400 per operated unit will give it approximately, exclusive of the tower and power house, if a separate one is to be built.

As there is no complete price list for power

apparatus, if a closer estimate is needed it is best to ask one of the signal companies to make a bid on the plant.

Where the railroad company is to install a power plant with its own men, the wire trunking, storage battery generator, trunking, stakes, and in fact everything not listed on the signal companies' catalogues, may sometimes be bought advantageously of other dealers. The cost of labor installing a power plant is anywhere from $50 to $75 per operated unit.

The signal companies will bid on material only, or material and installation, as requested.

The cost of automatic block signals varies with the number of signals used and the number of switches to be insulated. Some carefully prepared figures gotten out recently are as follows. The reader may take them for what they are worth:

Unbroken track circuit, per mile	$257.35
Each switch in circuit, additional	151.08
Each three-position signal in place, including lamp roundels, relay, foundation, connections to pole line, battery and battery shelter	475.28
Each one blade two-position signal in place, as above	421.75
Each two blade two-position signal in place, as above	495.06
Line wire in place—	
Bare copper wire, per mile	45.00
Weather-proof copper, per mile	70.00

There are usually from three to nine wires in each circuit.

These figures do not cover handling material and any extra track work which may be necessary in prepairing tracks for the track circuit, so in using them for estimating purposes it is best to add 10 per cent to cover contingencies.

CHAPTER XXI.

CONCLUSION.

The problem of railway signaling is a complex one, and not easily solved. As a problem, too, it has but recently come to the fore, so that a great deal of the work already done has been along experimental lines, resulting, as is always the case at such times, in much labor being thrown away.

The use of signals forms a language—a sign language it is true, but just as much a language as though it was written and spoken. This language is for the use and guidance of eminently practical men, men so thoroughly trained along certain lines of thought and action that, as the saying goes, a wink to them is as good as a nod. These men are so placed that they not only have a number of other responsible duties to perform besides interpreting signals, but are often in situations where the meaning of a signal must be grasped instantly. It is, therefore, greatly to be desired that the signals should speak in as few words as possible, and that those words should carry an unequivocal meaning, as in the case of military or naval manœuvers, where an officer's commands are simply "do this" or "do that," and no breath is wasted on superfluous explanations.

The watch officer on the bridge of a steamship, on finding himself approaching dangerously near another vessel, does not say to the helmsman, "To avoid running into that ship ahead put your helm a-port." He

simply says "port your helm" and leaves it to the helmsman to find out later why the order was given.

Like every other science which has been developed of late years since academicians became so thick in the land, railway signaling has been subjected to considerable scientific criticism. Some of the academicians, too, have even found their way into the signal departments of our railroads, and an attempt has been honestly made by them to develop a coherent and cohesive table of signal aspects which would show no inconsistencies under the critical inspection of the college professor. At the present such attempts appear to have rather over-reached themselves and there is a marked reactionary tendency, aiming at simplicity, even if a few inconsistencies have to be swallowed.

The English language itself is rife with inconsistencies. The Frenchman or the German, on taking it up, asks the question, How can I learn a language where p-l-o-u-g-h spells plow, t-h-r-o-u-g-h spells throo, t-o-u-g-h spells tuff, etc.

Esperanto is doubtless a language of much more correct construction than English, but does anyone really think that we are going to abandon English and substitute Esperanto for practical, every day use in this great, big, busy world of ours. Even the recent attempt of a President of the United States, backed up by the weight of the United States Government, to simplify our spelling has apparently made no impression on the practical mind of the every day man.

So it is with signaling. Never mind how thoroughly our academic friend of the signal profession develops a language of fixed signals, the practical man whose hand is on the throttle lever of an engine will group the aspects into three classes—those which mean proceed without limitation, those which mean

proceed cautiously, and those which mean stop. It does not make any difference to him whether a signal is a "stop and stay" or a "stop and proceed" signal *until after he has stopped.* There is time enough then for him to begin to differentiate.. It is quite possible to give a vast number of signs by the use of the semaphore. Chappé, who first developed it for visual telegraphy, gave one hundred and sixty-three different signals with it, but what good is it going to do to elaborate so when the man for whose use the signals are placed only needs three, or, at most, four, indications?

The use of signals on a railway is for one purpose, and one only, viz., to enable a great number of trains to move swiftly with safety. If trains moved as they once did on the Stockton and Darlington Railway, at three or four miles an hour, we could get along very well without fixed signals, but if we are going to run trains at forty-five, fifty or sixty miles an hour, experience has taught us that we cannot do so with safety unless we provide signal protection. The signal which will help us to accomplish this is what is needed. As far as I am aware we are not having railway accidents because the signal aspects we have used for years are not good enough, but because we do not have enough signals, such as they are.

In the foregoing pages I have endeavored to lay before the reader the general theory of American railway signal practice, with as much descriptive detail of the machinery used therein, and of the earlier practice from which that of today has grown, as my space permitted of.

That there is no branch of railroad engineering which is receiving more attention at the present time, cannot be doubted. That a properly developed signal system, thoroughly installed on a railroad, adds won-

derfully to the safety, as well as the facility of train movement, is now an established fact, and yet, as regards American railroads, signal engineering is still in its infancy.

The introduction of electricity into the field of signaling, although it opened up a vast range of new possibilities, has also to some extent had a deterrent effect on the progress of general signaling on American railroads. This statement may appear extraordinary to some readers, but I think I can show that I am right.

The cost of even the simplest mechanical signal arrangement, when carried out systematically over an entire railroad system, is enormous, and the introduction of electrical accessories has added vastly to the cost, without, in my opinion, adding proportionately to the safety secured by the signals.

To illustrate: A plain, single track railroad crossing protected by a mechanical interlocking plant, without any accessories whatever, affords a certain proportion of protection. That is, there is less likelihood of damage to property or injury to persons occurring at that crossing than if there was no interlocking. We add a mechanical time lock, which prevents the leverman from opening a derail in the face of an approaching train, making him, like the girl in Dickens' story—count "five and twenty" before he acts. This adds approximately four per cent to the cost of the plant, and in all probability adds that much more safety.

If, however, we add electric route locking, we increase the cost about 25 per cent, and add very little, if any more safety in practice, although theoretically no doubt we do.

This means that if for a given sum of money we can protect one hundred and twenty-five crossings with simple mechanical interlocking and time locks,

we can only protect one hundred and four if we use electric locking.

As most railroads, like other businesses, can devote only so much money to this sort of improvement, the extension of the field of signaling is being retarded by the extra cost of the electrical accessory.

Hasty and ill-advised legislation, too, has often defeated the very purpose for which it was intended, by compelling railroads to comply with certain impractical requirements *if they* installed signals, which would make the cost virtually prohibitive.

I wish to say here, distinctly, that this statement is not to be taken as applying to all legislation. Many states have very wise and just laws regarding the protection of grade crossings, junctions and drawbridges, and where such exist no one recognizes the benefit to be derived therefrom more readily than the signal engineer.

A case, however, which does apply, is that of the recently enacted, so-called, "nine hour law," by which Congress forbids any railroad doing an interstate business from keeping a block operator on duty more than nine hours out of twenty-four. This means that where a manual block station is to be kept open twenty-four hours a day three men must be employed there instead of two, as was the former practice. This is a direct increase of fifty per cent in the cost of operation and has probably done more to retard the advance of manual block signaling than any one thing that could have been done.

The work of the ordinary block operator is certainly not heavy.

He has a great deal of spare time on his hands while on duty which he may devote to reading and other mental relaxation. Any one who has ever worked at night around a railway station has some idea of the number of games of chess and checkers

going on over the wires during the wee small hours of the morning.

Had the law been drawn to read about as follows, viz.: that no railroad should keep a block operator on duty more than twelve hours out of twenty-four and not more than seventy-two hours during any one week, it would have accomplished all that the present law can possibly accomplish and would have appealed to the sense of justice of every railroad officer. This would mean that each operator would get one day a week off. The railroads would have had to employ an extra man for each six regular men, whose duty it would have been to travel from station to station, relieving, or, as the expression is, "spelling" each regular man as his turn came around.

I have recently, since commencing to write this chapter, read a little book by Mr. Raynar Wilson, English signal engineer and author, entitled "The Safety of British Railways." No American can read what Mr. Wilson says without being forcibly impressed by two points which stand out *par excellence* beyond all the rest of the work.

1. That for thirty-five years there has been a steady decrease in the accidents per train mile on the railroads of Great Britain, until a point has been reached where a person traveling by rail may be said to be safer than he is sitting at home in his own house.

2. That this wonderful condition has been developed by the railroad managements, voluntarily, and unhampered by acts of Parliament—two general laws bearing on the use of safety appliances having been enacted during thirty-five years. Both these laws are far-reaching, and well-drawn, so that they have required no amendments.

There is no reason to believe that the managements of American railroads like to pay out claims for loss and damage to freight and for personal injuries any

more than their cousins over the water, and were it not for the uncertainty which is always present as to what Congress and the various State Legislatures will do next, there is little doubt that signaling in this country would be much further advanced than it is.

Another retarding element, and one for which the railroads themselves are largely responsible, is the lack of uniformity of practice. The American Railway Signal Association, although it has done much good work during its short life, has not yet succeeded in establishing uniformity in either signal aspects, indications or colors. The three position signal is as violently opposed by some as it is supported by others, and the same may be said of the upper and lower right hand quadrant, while a sect has recently appeared strongly advocating an upper *left hand* quadrant signal. In fact, our national spirit of restlessness and wishing a change appears as strongly in our signal practice as in other ways. There is no doubt that so long as the members of this Association cannot agree amongst themselves as to what is the best practice, a great many signal engineers are diffident about recommending further installations at the present time.

Being, I suppose by nature, conservative in all things, I am free to confess that I fail to see the necessity for any change in what has been heretofore the most general of any practice in this country, viz.: the lower right hand quadrant sixty degree signal. I believe that the painting of all blades, both home and distant, yellow, or some other conspicuous color, would be an advantage, and the general adoption of a green light for the clear indication at night would also be a good thing. These changes can be made at a trifling expense in any existing installation. The ninety degree signal, either upper or lower quadrant, I consider a positive step backwards. Even where the

arm plate is of such shape as to carry the blade some little distance away from the mast, the blade and mast parallel to each other do not make as conspicuous a signal by any means as where they form an angle with each other.

The three position signal was first installed and has had its fairest tryout on a railroad whose signal officers are today foremost in advocating a signal system in which each semaphore *must display two lights at night.* This would indicate that their experience with the one lamp mast of the three position system had not proven entirely satisfactory.

By far too few American signal engineers have had actual experience in the operating department of a railroad, and consequently many of them fail to grasp the real utility of signals. For the same reason, much thought, time and money has been spent, I cannot but believe useless—in attempts to make our signal devices fool proof, by doing away with the "human equation."

As a distinguished signal engineer has tersely put it, "In this country we spend millions in an endeavor to make our apparatus fool proof, while in England they spend hundreds to eliminate the fool, and appear to get better results."

There is no doubt that American railroad managements could advantageously give more attention to educating their train and engine men as well as their block operators in a better understanding of the meaning and advantage of fixed signals of all sorts. If the same attention was given to this subject as is being given to instruction in the use of air brakes, much good, I am certain, would result.

As regards the use of automatic block signals. My observation, and I have watched them for many years, both from an operating and from an engineering point of view, does not lead me to believe that they are the

panacea for all the ills on a railroad, which for a long time they were given the credit of being. Statistics, carefully compiled by a special committee of the Interstate Commerce Commission, showed that for the period covered more collisions occurred per train mile in automatic block territory than in manual block territory. There is more than one reason by which such a condition may be explained. With manual block signals, engine runners know that when a signal is set at stop, it is because the block operator in charge of it set it so, and that, in case they disregard the signal, the operator in self-defense will report it. Again, manual block signals are, as a rule, placed at much less frequent intervals than automatic signals, and are always at a station interlocking tower, or block cabin, the location of which is well fixed in the runner's mind. A manual block signal, too, is a "stop and stay" signal, which means that when displayed at stop, an engine runner is forbidden to pass it until it is cleared, or he is given written authority to do so.

With automatic signals, on the other hand, there is no one permanently stationed in their vicinity whose duty it is to report an engine runner who fails to stop for one; they stand out in isolated places without any distinguishing landmark near, so that a man who is looking after an injector or gauge cock may slip by one without noticing it, and the rules of every railroad allow the runner, after he has stopped for an automatic signal, to proceed immediately without waiting for it to go to clear. The temptation to a man with a poorly steaming engine and a heavy train, knowing this rule, to fail to come to the stop, is at times well nigh irresistible. I have more than once subjected myself to ridicule by making the statement that I considered the automatic block signal as representing a transition, and that I did not consider that it was here to stay, but would eventually be sup-

planted by a manual block system. Nevertheless, I shall here repeat that statement, and let it go down into history as my honest opinion. By this I do not wish to be understood as meaning that the automatic signal will ever entirely vanish. Around large terminals, where very short blocks are necessary on a six or eight track line, the automatic signal may be used to advantage. In such cases a large enough maintenance force to keep the signals in good working order at all times can be kept on hand, but from long stretches of line through the country, I believe they will some day disappear.

A great many American railroads, especially in the West, have very heavy traffic, all in one direction at certain hours of the day. For instance, it is every railroad's endeavor to arrange its schedules so as to bring its passenger trains into large terminals such as Chicago, St. Louis, St. Paul, Kansas City and Omaha, early in the morning. At the same time, all of the points named being live stock centers, stock trains are being hurried in for the early markets, as well as packing house products; and merchandise, for city delivery, is wanted at receiving freight houses as early as possible.

In the evening, on the other hand, this condition is reversed. Passenger trains are arranged to leave during the late afternoon and early evening, so that merchants who have come in on the morning trains may, after having a day for business in the city, return to their homes by the next morning. Empty stock cars are being rushed back to the loading points and the city merchandise loaded during the day is started out as soon as the freight houses close, so as to get as far as possible on its journey by next morning.

With double track railroads leading into such places, therefore, as long as the regular direction of traffic is rigidly adhered to, one track is virtually idle

for many hours at a time while the other may be congested to the point of causing serious and even expensive delays.

With railroads as much as any other business, it is true economy to keep all of the plant earning money all of the time, and the practice of reversing the direction of traffic on one track at such congested times is fast becoming popular.

An automatic block system does not lend itself readily to such an arrangement, while a well organized manual block system does, although the movements against the current are controlled by train orders instead of by signals. By having no crossovers between the two tracks, except at block stations, trains may be given dispatchers' orders and crossed over at any point by the block operator, especially if the crossover switches are interlocked. The block operator being responsible for the proper manipulation of the switches, and also being advised of all train movements for a block on either side of him, is in the best position possible to detect a mistake in an order if one should be made. As orders given to engine and train men at such times are for immediate action, they are not subject to the objections raised against a dispatching system, where orders are given on which the recipient is not expected to act, possibly for an hour or maybe a longer time than that during which he may forget that he received the order. Where advantage is systematically made of the idle time of one track in this way, I have never yet heard of an accident's occurring through such an arrangement.

As long as there was no accepted method of communication between stations except by telegraph, the introduction of manual block systems was seriously retarded by the scarcity of telegraph operators. Professional telegraph operators who would accept positions as block operators at the wages which railroads

could afford to pay for such service were, as a rule, beginners—young men who expected, as soon as they became proficient enough, to be able to secure better pay in other positions. The introduction of the telephone for block purposes has made it possible for railroads to use a different and more permanent class of men for this work, which is bound to result in more efficient service in the future.

The danger point on a railroad is within station limits. It is there that irregular movements are made. That is, switching is done there and trains, engines or cars are crossed over from one track to another. Almost all switches connecting with main tracks are there. There is probably no one thing by which a railroad can secure more additional safety for its money than by interlocking all main track switches and putting their proper manipulation in the hands of one man. By careful consideration of the operating conditions, most of the important main track switches at a station can be brought within the limits of a mechanical interlocking plant. The exception to this is the far out switches at the ends of passing tracks. Unless power interlocking is used, the cost of which is generally prohibitive, these cannot be operated from the station. It is well, therefore, to provide distant signals which may be bolt locked with or connected to these switches with facing point locks, as described in an earlier chapter. At stations so situated that the view of the station limits from the main line is obscured, a home and distant signal placed outside of the station limits, to be set at stop and caution by trainmen employed on trains using the main track at the station, will be found an additional and valuable safeguard. Automatic signals are sometimes used for this purpose, or if it is not advisable to install a track circuit, and the distance that these signals must be placed from the levers which operate them is

so great that the signals cannot be operated with certainty by mechanical means, electric signals operated in the same manner as power distant signals are operated, may be used.

The duties of a signal engineer are such that it is a much mooted question whether he belongs in the engineering or operating department of a railroad. This is a matter that railroads generally differ about. Whether he reports to an operating or an engineering head, it is the universal custom to have him take charge of any signal construction work which may be contemplated. He should, therefore, be in close enough touch with the construction department to be able to give advice as to the most advantageous layouts for switches and sidetracks at points where interlocking plants and block signals are to be installed.

My own experience has been that it is much cheaper and more satisfactory in every way for a railroad company to employ its own signal construction force and install its interlocking and signal work itself, buying the material on the open market to suit its own standards.

Some large companies prefer, however, to contract for all their new work.

I have not said anything in regard to the construction of towers because this is a matter which on most large railroads is handled by the architect or superintendent of buildings and not by the signal engineer. There is really very little that can be said from the signal engineer's point of view. Almost any form of construction should satisfy him, provided he is given a solid support for the machine, ample window space and a building of solid enough construction to insure its keeping warm during cold weather. In my opinion many railroads build their towers in a much more expensive and elaborate manner than is necessary. Where a brick or concrete building is to be

used, it should be made amply large enough to allow for later enlargements to the machine. My rule is to build no such tower for less than a forty lever machine, even though a much smaller machine is to be used for the time being. Frame towers may be enlarged very cheaply so that it hardly pays to build them larger than necessary for present requirements. The use of hot water heaters in interlocking towers is becoming quite popular. It can be recommended as economical and cleanly.

Where a power interlocking machine is used and the storage battery is to be placed in the basement of the tower, the rack or case for the battery cells should be arranged so that light may be had on the jars from each side. This enables the maintainers to see through the electrolyte and watch the performance of the plates.

Towers should never be placed closer than eight feet from the nearest rail to the face of the tower. If there is a likelihood of another track's being built on the tower side of an existing track, the tower should be placed a minimum distance of 23 feet from the center of the latter.

Lamps with very large hoods or shades, which may be suspended from the ceiling, are to be had. These give a good light in the operating room but do not throw the light out through the windows. Their use will be found very satisfactory. The manipulation chart, and all notices which it is necessary to post in the operating room, should be neatly framed and the levermen should be compelled to keep the tower tidy. The locking beds of Saxby and Farmer machines should be covered with a canvas or wooden cover to protect them from sand and dirt which would cut the locking dogs and crosslocks.

Since the American Railway Signal Association issued its standard specifications for mechanical inter-

locking material, the parts manufactured by any of the companies are interchangeable. This Association has also sent out a standard specification for contractors to work to, so that uniform work may be had from any of the companies doing business in this line.

These specifications, for both mechanical and power interlocking will be found in the appendix.

THE END.

SPECIFICATIONS FOR MECHANICAL INTERLOCKING.

GENERAL.

1. Specifications.

Adherence.—All the work herein outlined is to be done in strict accordance with the specifications, the accompanying plans and such instructions as may be given from time to time by the purchaser.

Spirit.—The nature and spirit of these specifications are to provide for the work herein enumerated to be fully completed in every detail for the purpose designed; and it is hereby understood that the contractor in accepting the contract agrees to furnish any and everything obviously necessary for such construction.

Special Work.—The purchaser will furnish a description and drawings of all special work.

Copies.—Duplicate copies of these specifications will be furnished by the purchaser with request for tender.

2. Drawings.

Preliminary.—The purchaser will furnish with each copy of the specifications, copies of all drawings in dictating the work to be performed.

The contractor shall examine these drawings, call the purchaser's attention to any apparent errors and ascertain the purchaser's wishes regarding the same before submitting a tender.

Final.—After the contract has been awarded, the contractor shall submit three (3) sets of drawings showing the proposed arrangement or construction, which require the purchaser's approval, one set of which will be approved and promptly returned. Should changes in these drawings be necessary to meet the requirements of the specifications, one set will be promptly returned with such changes indicated in writing, and the contractor may proceed with the work when such corrections have been made.

The contractor shall furnish four (4) sets of working drawings for the purchaser's files and upon request two (2) additional sets for the file of each other interested company.

Suitable framed manipulation chart and track diagrams shall be furnished in place by the........................

3. Supervision.

Supervision.—All work shall be under the supervision of the purchaser's accredited representative hereinafter referred to as the supervisor.

Foreman.—The foreman of installation, and his men, shall be satisfactory to the supervisor.

Instructions.—The foreman of installation shall receive and act upon all instructions given by the supervisor in writing.

3. Supervision.

Inspection.—All material and workmanship will be inspected thoroughly and carefully, and the contractor will be held at all times to the spirit of the specifications.

The supervisor shall be given free access to all parts of the work during the process of construction.

*The purchaser will make a final inspection and tests within three (3) days after the completion of the work. Any defects or omissions noted during this inspection shall be made good by the contractor without extra charge before the work will be accepted.

Defective Work.—The contractor, upon being so directed by the purchaser, shall remove, rebuild, or make good, without charge, any defective work.

*Acceptance.—The purchaser will issue written acceptance of the plant as soon as his inspection has shown that all work has been completed in conformity with plans and specifications.

4. Alterations.

Specifications.—The purchaser reserves the right to make changes in plans and specifications. All such changes shall be handled in the same manner as the originals.

*Alterations involving a change in the plans which will increase or decrease the amount of material to be furnished, or work to be performed by the contractor, shall be classed as extras, and such allowances shall be made as may be mutually agreed upon in writing.

5. Permits.

The purchaser will obtain all necessary permits. Work requiring permits shall not be prformed until same have been provided.

6. Accidents.

Precaution.—The contractor shall place sufficient and proper guards for the prevention of accidents and shall put up and maintain at night suitable and sufficient lights, as specified in Article 16.

Responsibility.—The contractor shall save the purchaser harmless and relieve him from all responsibility for any damage, injury, or loss suffered by any person or persons in the employ of the contractor while such person or persons are engaged in the construction of interlocking, unless such damage, injury, or loss is caused by the negligence of the purchaser.

7. Patents.

*Patent Royalties.—The contractor will pay all patent royalties on patented articles furnished by him, and will

protect the railroad company from all patent right claims.

8. Payments.

*First Payments.—The purchaser will pay .. per cent of the contract price upon the receipt of the material at destination.

*Second Payment.—The remaining .. per cent of the contract price will be paid within .. days after the acceptance of the plant.

*Extras.—Payments for extras will be made in the same manner as prescribed for in the contract price.

9. Contract.

As soon as possible after the award is made, the contract, in accordance with the accompanying form, will be presented in duplicate to the contractor for his signature, after which both copies will be signed by the purchaser and one of them will be returned to the said contractor.

DETAIL.

10. Intent.

The intent of this specification is to clearly describe all of the material and labor required for and the results to be obtained by the complete installation of a mechanically operated interlocking plant at .... on the lines of the .... Railroad, as shown in the plans and supplementary data hereto attached.

Results. Note.—This space is provided for a complete general description of the plant and all its adjuncts, and of the operating results to be obtained therefrom.

11. Supplementary Data.

Practice.—The contractor's recognized best practice shall govern except as herein otherwise provided. The plans, drawings, and detail specifications attached to and forming a part of this specification are:

....

....

....

12. Material and Workmanship.

When it is necessary or desirable to use apparatus not heretofore in use, the contractor shall submit drawings of the same with his proposal, and the acceptance of such proposal shall constitute acceptance of such new devices.

All material and workmanship shall be first class in every respect.

12. Material and Workmanship.

*The contractor shall furnish for replacement free on board at works any apparatus or material of his own manufacture or furnished on his own specifications, which shall prove de-

fective after having been in service one year or less, provided it was used for its intended purpose.

The contractor's standard apparatus shall be used, except as herein otherwise specified.

13. Transportation.

The purchaser will .... furnish transportation for the men engaged in, and necessary tools and material required by, the installation of the plant over the following railway lines:

....
....
....
....

Shipment and Handling.—Tools and material are to be shipped

To ....
Care of ....
At ....
Via ....
Marked ....
Freight Prepaid to..

The purchaser will unload and properly house only such material as arrives before the contractor's men.

The use of the following cars will be permitted under the restrictions and conditions of Articles Nos. 6 and 16, unless otherwise indicated in this paragraph:

	Number.	Furnished by
Motor cars	....	....
Velocipede cars	....	....
Hand cars	....	....
Push cars	....	....

When contractor is not permitted to use hand cars or push cars, the purchaser will, at its own expense, distribute all material to the point of use upon receipt of notification from and under supervision of contractor's foreman.

When contractor shall call upon the purchaser for the required number of cars for the return of tools and unused material, and same will be furnished in .... days, after which time the purchaser will, at his own expense, care for and load all tools and material.

14. Track Work.

The purchaser will furnish:

All switches, derails and movable point frogs in place adjusted to the required throw.

All ties in place for the support of the apparatus.

All rail braces, and will install all except those located on tie plates furnished by the contractor.

The purchaser will move all ties which interfere with installation of the interlocking apparatus or connections.

The purchaser will remove all guard rail clamps, rail braces, anti-creepers and lips, and otherwise prepare the rail for the installation of detector bars.

The purchaser will remove and replace all switch and tie rods (other than front rods on interlocked switches) requiring a change in location, the application of insulation, adjustment brackets or other alterations.

15. Obstacles.

The purchaser will do all preliminary grading, provide adequate drainage, and blast and remove all solid rock that will interfere with the placing of the interlocking apparatus or connections.

*Where it is necessary to make an alteration or move any part of an existing structure, the same will be done by the purchaser.

16. Traffic.

The contractor shall not unnecessarily delay or interfere with traffic. When it becomes necessary for contractor to perform any work which may endanger traffic, the contractor shall notify the purchaser and shall not proceed with said work until traffic is protected.

The purchaser will promptly arrange to protect traffic upon request of contractor.

17. Completion.

The contractor shall notify the purchaser, in writing, not less than seven (7) days before the plant will be ready for service.

The contractor shall put the plant in service under the supervision of the purchaser, and shall leave .... competent men on duty for .... hours thereafter.

The purchaser will maintain and operate the plant as soon as it is put in service.

The purchaser will put the plant in service, providing this cannot be done within three (3) days after the completion of the contractor's work.

The contractor shall remove and dispose of all excess earth and all refuse made by the contractor's men or shall load on cars, where disposal cannot be made on right of way within interlocking limits.

18. Provided by Purchaser.

a ....

b ....

c ....

d ....

e ....

Note.—Items to be provided by purchaser shall be assembled and filled in at this point.

19. Tenders.

Sealed tenders for the work covered by these specifications will be received:

by ....

at ....

up to .... hour on the .... day of .... month .... of ...., at which time and place said tenders will be opened. Bidders are invited to be present.

Note.—This space is provided for a complete description of the division of the tenders for the different portions of the work.

a ....

b ....

c ....

d ....

The purchaser reserves the right to reject any and all bids.

20. Interlocking Stations.

A .... building .... stories high and .... x .... inside dimensions, with a .... frame for supporting the machine, shall be built by the .... in accordance with specifications and drawings No. .... for building and drawings No. .... for frame.

A .... foundation for the building and leadout supports shall be built by the .... in accordance with specifications and drawings No. .... Leadout supports shall be furnished in place by the .... accordance with drawings No. ....

21. Machine.

(a) It shall be of the preliminary latch-locking type; levers shall be numbered from left to right, like parts of machine of same type shall be interchangeable, and all bolts shall be provided with jamb or lock nuts.

(b) All levers shall be arranged so that they can be removed without interfering with other levers.

(c) Levers shall be ...... ft. ...... in. in length from end of lever handle to center pin, and center pins shall be one and one-quarter (1¼) in. in diameter.

(d) All levers shall have equal and uniform throw, and shall be so arranged that connections may be made to front or back of lever. Tail levers for pipe connections shall be drilled to provide for eight and three-quarter (8¾) in., nine and three-quarter (9¾) in. and ten and three-quarter (10¾) in. stroke. Tail levers for wide connections shall be drilled for eight and three-quarter (8¾) in., ten and three-quarter (10¾) in., twelve and three-quarter (12¾) in.,

fourteen and three-quarter (14¾) in., and sixteen and three-quarter (16¾) in. stroke.

(e) One lever shall operate not more than one signal, two pairs of switch points, one hundred and six (106) ft. of detector bars at single switches, or one hundred and fifty-six (156) ft. at slip switches, four rail locks, one switch and lock movement, two bridge locks, or two eight (8) way bridge couplers.

(f) Provision shall be made for one tappet or cross-locking bar, one lever shoe pin and caps, and one locking bar extending full length of the machine for each lever or space.

(g) The locking shall be distributed as uniformly as possible in the locking bed.

(h) Locking shafts on S. & F. type shall extend .... ins. out from back rail and shall be drilled .... ins. from end of applying electric locks, holes shall be .... ins. in diameter and horizontal with levers on center.

(i) The front, back and intermediate rails supporting locking bed of S. & F. type shall be provided with one way caps.

22. Leadout.

(a) Rocking shaft, deflecting bar, or a combination of deflecting bar and vertical crank leadout, shall be furnished.

(b) Rocking shafts shall be made from two (2) in. square, rolled steel with movable bearings and movable crank arms. Straight and bent shaft arms shall be .... iron, eleven and three-quarters (11¾) ins. long, center to center. Rocking shaft bearings shall be so arranged that both ends of all rocking shafts shall be supported, and no more than six (6) ft. of rocker shaft shall be unsupported.

(c) Rocker shaft stands shall be made of cast iron, center of bearing to the base of stand shall be fifteen (15) ins., bases of stands shall be symmetrical and shall be cored for four (4) three-quarter (¾) in. bolts spaced ...... x ...... in. centers. Bearings shall be provided with one (1) way caps and shall be attached to stands with two (2) five-eighth (⅝) in. bolts.

(d) Vertical leadout chain wheels shall be made of malleable iron and shall be ten (10) ins. in diameter. Stands for vertical chain wheels shall be drilled for bearings ten (10) ins. and twelve (12) ins. above base of bearing; bases shall be cored for two (2) three-quarter (¾) in. bolts ...... in. centers.

(e) All leadout appliances shall be securely fastened to leadout supports by three-quarter (¾) in. bolts, bolt heads shall be placed underneath.

(f) All down rods shall be vertical with offset jaws, so

that they may be connected to lever for either eight and three-quarter (8¾) in. or nine and three-quarter (9¾) in. stroke, and shall be connected to the eight and three-quarter (8¾) in. stroke hole.

(g) Shackles shall be connected to tail levers with standard seven-eighth (⅞) in. by two and one-quarter (2¼) in. pins for all wire lines, and sufficient movement of wire line shall be provided to successfully operate all wire connected signals.

23. Pipe Line.

(a) One inch pipe shall be used for connections to switches, derails, movable wing and point frogs, detector bars, locks, bridge couplers, and high home and .... signals.

(b) Pipe lines shall be straight where possible and shall not be placed less than four ft. six in. (4′ 6″) from gage line, except where the line runs between tracks or permission is granted by the purchaser. On draw spans and approaches they shall be kept as far from the gage line as conditions will permit.

(c) Where possible pipes in main pipe line shall be run so that they will lead off on track side in regular order.

(d) Top of pipe carrier foundations in main pipe line shall be one (1) in. below base of rail where conditions will permit.

(e) All cranks, compensators, and deflecting bars in main pipe run shall be so located as to leave field side clear for wires, trunking and additions.

(f) Pipe lines shall be laid two and three-quarters (2¾) ins. between centers and shall be supported on pipe carriers placed not more than seven (7) ft. centers. The distance from base on which pipe carriers are supported to the center of pipe line shall be four and one-quarter (4¼) in.

(g) Couplings in pipe lines shall be located not less than twelve (12) in. from pipe carriers with lever on center.

(h) Where so specified on plans at points where pipe lines cross under tracks, roads, platforms, etc., standard one (1)-in. pipe shall be run inside of standard two (2) in. galvanized iron pipe, provided at each end with a stuffing box, which shall be provided with an oil inlet, and shall be attached to the pipe by standard pipe coupling. Design shall be such as to permit of standard spacing of pipe lines two and three-quarters (2¾) in. between centers.

(i) Where so specified I-beam track supports shall be used where pipe lines cross under tracks, and I-beam construction shall be built as per plan No. .... attached, and shall be furnished and put in place by the Purchaser.

(j) Except where otherwise provided, pipe lines run across tracks shall be arranged to permit standard spacing and proper tamping of ties.

(k) Pipes leading across tracks shall be supported by transverse pipe carriers fastened to top of ties where practicable.

(l) Turns in pipe line shall be made with radial arms, cranks, or deflecting bars as follows:

(m) Angle of Deflection:

0	degrees	to	11	degrees
11	degrees	to	33½	degrees
33½	degrees	to	56	degrees
56	degrees	to	78½	degrees
78½	degrees	to	90	degrees
0	degrees	to	30	degrees
30	degrees	to	75	degrees
75	degrees	to	105	degrees
105	degrees	to	140	degrees
140	degrees	to	180	degrees

Deflecting bars with tang ends:

22½ degrees deflecting bars with eye ends.
45 degrees deflecting bars with eye ends.
67½ degrees deflecting bars with eye ends.
90 degrees deflecting bars with eye ends.
15 degrees radial arm cranks.
60 degrees acute angle cranks.
90 degrees standard cranks.
120 degrees obtuse angle cranks.
180 degrees equalizing arms.

(n) Pipe lines shall be installed in accordance with temperature diagram, and table of equivalent lengths used in compensating pipe lines when crank arms are of unequal length.

(o) Deflecting bars, radial cranks, pipe, stuffing boxes, tang ends, plugs, and couplings shall be Railway Signal Association Standard.

(See specifications for 1-in. pipe couplings.)

24. Pipe Carriers.

(a) Pipe carriers for main pipe runs shall be of the anti-friction type, and constructed of individual sides, top and bottom rollers; sides shall be connected together at top; and in contact, but not connected at bottom; bases shall be cored for two (2) one-half (½) in. lag screws .... in. centers, and fastened to foundations with two (2) .... x .... in. lag screws.

(b) Transverse carriers shall be constructed of individual sides, top and bottom rollers, sides shall be supported by a wrought or malleable iron bearer, and connected together by a one-half (½) in. pin through center of bottom roller, connected to bearer, with one-half (½) in. bolts, and fastened to foundations with two (2) three-quarter (¾) by four (4) in. lag screws.

(c) The pipe carrier shall be constructed of malleable or wrought iron frame and bottom roller, assembled together by one-half (½) in. pin through center or roller, and fastened to foundation with two (2) one-half (½) in. by two and one-half (2½) in. lag screws.

(d) All pipe carrier sides and bottom rollers shall be made of malleable iron.

25. Compensation.

(a) Compensation shall be provided for all pipe connected units or apparatus where same is necessary to insure proper operation.

(b) Unless compensation is otherwise provided for, a lazy jack compensator shall be provided for each pipe line over fifty (50) ft. in length and under eight hundred (800) ft., with crank arms ten by thirteen (10x13) in. centers. From eight hundred (800) to twelve hundred (1,200) ft. in length, crank arms shall be ten by sixteen (10x16) in. centers. Pipe lines over twelve hundred (1,200) ft. in length shall be provided with additional compensators. No more than seven hundred and twenty-five (725) ft. of pipe shall be compensated by an eleven and three-quarter (11¾) by eleven and three-quarter (11¾) in. crank.

(c) No more than one horizontal compensator or two vertical compensators shall be mounted in one stand.

(d) Compensators shall have one (1) sixty (60) degree and one (1) one hundred and twenty (120) degrees angle cranks, with bosses two (2) in. thick, and eleven (11) in. connecting link, mounted in cast iron bases, having top of center pin supported. The distance between center of pin holes shall be twenty-two (22) in., and bases shall be cored for four (4) three-quarter (¾) in. bolts spaced .... x .... in. centers.

26. Horizontal Cranks.

Cranks shall be made of wrought iron and drilled eleven and three-quarters by eleven and three-quarters (11¾x11¾) in. center to center, with boss two (2) in. thick. They shall be mounted in cast iron bases, having top of center pin supported. Not more than two (2) cranks shall be mounted in

the same base, and no more than one crank mounted on one center. Bases shall be cored for four (4) three-quarter (¾) in. bolts, spaced .... x .... in. centers.

27. **Vertical Cranks.**

Cranks shall be made of wrought iron and drilled eleven and three-quarters by eleven and three-quarters (11¾x11¾) in. center to center, with boss two (2) in. thick. They shall be mounted in one and two way cast iron stands and drilled for bearings .... in centers above base, and base cored for four (4) three-quarter (¾) in. bolts, spaced .... x .... in. centers.

28. **Switch and Lock Movement.**

Switch and lock movement shall be securely bolted to five-eighth by twelve by .... ft. (⅝"x12"x..........') iron plates, and shall be placed on outside of track .... ft. .... in. from gage of nearest rail bolted to ties.

29. **Deflecting Bars.**

(a) Deflecting bars shall be made in one way multiple unit type; bars shall be made of one and one-quarter (1¼) in. square steel, and designed for ten (10) in. stroke, and shall be bent at the following radii:

22½ degree, radius seventy-two (72) in.
45 degree, radius thirty-six (36) in.
67½ degree, radius twenty-four (24) in.
90 degree, radius eighteen (18) in.

(b) All cranks, compensators, deflecting bars, switch and lock movement, and stands shall be Railway Signal Association Standard.

30. **Jaws and Lugs.**

(a) Except where otherwise specified, solid jaws shall be used for connections to all cranks, compensators, deflecting bars, couplers, rail locks, pipe connected levers, and balance levers.

(b) The body of all jaws shall be of wrought iron, one and eleven thirty-seconds (1 11/32) in. in diameter, with tang and thread for coupling to pipe.

(c) The sides of solid jaws shall be parallel for three (3) in. from center of pin hole, and length of solid jaws shall be nineteen and one-half (19½) in. from center of pin hole to center of first rivet hole.

(d) Screw jaws shall be used as follows: one for each switch connection to bolt lock, front rod, lock rod, switch and lock movement, detector bar connection, in signal line on each side of bolt lock, and in each high signal down rod, and shall be located as close as possible to the unit to be adjusted.

(e) Screw jaws shall be made of .... iron, with

hexagon shank ends the same size as the outside dimension of the one and one-quarter (1¼) in. standard jamb nuts.

(f) The sides of screw jaws shall be parallel for five (5) in. from center of pin holes, and length of screw jaw shall be nineteen and one-half (19½) in. from center of pin hole to center of first rivet hole with shank of jaw on center of thread.

(g) Each screw jaw shall be provided with jamb nut.

(h) Pipe lugs shall be made of wrought iron one and eleven thirty-seconds (1 11/32) in. in diameter, fitted with thread and tangs for coupling to pipe, and minimum distance from center pin hole to center of first rivet hole shall be .... in.

(i) All jaws, lugs and tangs shall be Railway Signal Association Standard.

31. Offsets.

Offsets in pipe lines shall be made in body of jaws, or in iron rod one and eleven-thirty-seconds (1 11/32) in. in diameter. The total offset between any two supports shall never exceed three and one-half (3½) in., minimum distance between ends of offset shall never be less than twice the amount of the offset. Offsets in cranks and compensators shall be avoided as far as possible.

32. Locks.

(a) Facing point locks shall be used on all switches, derails, movable wing and point frogs, except where otherwise specified on plans. Locks shall be arranged to lock all switches in normal and reverse position, and all derails in reverse or closed position only.

(b) Facing point lock stands shall be placed on outside of track, twenty-eight (28) in. from gage and bolted to tie through a tie plate, placed on top of tie, and tie plate shall extend under and support the nearest rail and point. Facing point lock stands shall be arranged to support the plunger on each side of lock rod to support the lock rod on each side of the plunger, and bases shall be cored for four (4) three-quarter (¾) in. bolts........x........ in. centers.

(c) Facing point lock plungers shall be one (1) in. in least dimension, with square end and nineteen (19) in. in length from center of pin hole to end, have full stroke of pipe line, and stand one (1) in. clear of lock bar when switch is unlocked.

(d) Lock rods shall run direct from front rods into lock stands, and shall be of the double adjustable type. Holes or notches in lock rods shall have square edges and shall not be more than one-sixteenth (1/16) in. larger than plunger.

(e) When electric locking or switch circuit controllers

are not used, all facing point switches, movable wing and point frogs on high speed routes shall be bolt locked with signals governing such routes; and all facing derails shall be bolt locked with all signals governing over them.

(f) All bolt lock stands shall be made in one (1) way multiple unit type, and cored for four (4) three-quarter (¾) in. bolts.

(g) Switch bar in bolt lock shall be made of mild steel .... x .... with .... in. notch, and have an independent connection to switch point and shall not be connected to front, lock, throw rods, or point lugs, if front rod is attached to them.

(h) Signal bar in bolt lock shall be made of mild steel .... x .... with .... in. notch, and be a part of the pipe line, and not lugged or looped in.

(i) Lock stands, plungers, front rods, lock rods, and switch lugs shall be Railway Signal Association Standard.

Note.—Where local conditions are such that it is not practicable to install bolt locking the committee recommends circuit controllers on switches, derails, movable wing and point frogs, and their respective operating levers with electric locks on lock levers to insure that switches have responded to the position of the lever, or where slotted signals are used, they shall be controlled by circuit controllers on switches, derails, movable wing and point frogs.

33. Tie Plates.

(a) Three tie plates shall be used for all switches and derails, and shall be located as follows: one on point tie, and one on nearest tie on either side. Four tie plates shall be used for each set of movable point frogs, and shall be located as follows: one on point tie, and one on first tie back of the point tie for each pair of points.

(b) Tie plates shall be one-half in. by six in. by........ (1″x6″x............); butt plates shall be .... x .... x .... and drilled for .... in. rivets. Riser plates shall be .... x .... x .... and drilled for .... in. rivets. All tie plates shall be fitted in place and securely fastened to the ties with .... three-quarter by four (¾x4) in. lag screws.

34. Rail Braces.

Rail braces shall be furnished by the Purchaser.

35. Tie Straps.

(a) At all switches, derails, movable wing and point frogs, tie straps shall be used, to tie all crank, rocker shaft, point and intermediate ties together.

(b) Tie straps shall be one-half by two and one-half

($\frac{1}{2}$x2$\frac{1}{2}$) in. iron, placed on top of ties and fastened to the ties with three-quarter by four ($\frac{3}{4}$x4) in. lag screws.

36. Detector Bars.

(a) Bars shall be located as shown on .... Plan No. .... date .... attached hereto, unless otherwise specified.

(b) Bars on curves shall be located on inside, outside or both sides of curve as determined by local operating traffic conditions.

(c) Detector bars shall be arranged to give fifty-three (53) ft. continuous protection for all switches, derails, movable wing and point frogs, and shall lap the switch points a distance equal to the stroke of the bar.

(d) Detector bars shall be three-eighth by two and one-quarter ($\frac{3}{8}$x2$\frac{1}{4}$) in. steel, have one beveled edge, square ends, and bolted joints, and shall be made up in eighteen ft. sections.

(e) Bars shall be drilled one (1) in. from bottom of bar to center of hole for three (3) one-half ($\frac{1}{2}$) in. countersunk head bolts or rivets. The first hole shall be one (1) in. from end to center and two (2) in. between centers of holes. Splice plates shall .... be used; they shall be of wrought iron one-half by two by twelve ($\frac{1}{2}$x2x12) in., riveted at one end of bar with three (3) one-half by one ($\frac{1}{2}$x1) in. countersunk head rivets and attached to intermediate sections by three (3) one-half by one and one-quarter ($\frac{1}{2}$x1$\frac{1}{4}$) in. countersunk head bolts, with nuts held in place by nutlocks.

(f) Driving pieces shall be made of wrought iron arranged for one and eleven thirty-second (1 11/32) in. jaw connections. The part where the jaw is connected shall be three-quarters by two by three ($\frac{3}{4}$x2x3) in.; and part riveted to bar shall be one-half by two by six ($\frac{1}{2}$x2x6) in., drilled for three (3) one-half ($\frac{1}{2}$) in. rivets; one (1) in. from end and two (2) in. between center of holes. Offset from bar to jaw connection shall be one and one-half (1$\frac{1}{2}$) in.

(g) Driving pieces shall be placed midway between two (2) clips in space not equipped by joint, and the driving rod shall have not more than seven (7) ft. unsupported.

(h) Fifty-three (53) ft. bars shall be mounted on sixteen (16) .... type rail clips, and a proportionate number of clips shall be used for longer or shorter bars.

(i) Centers of rail clips shall be placed eight (8) in. and twenty-six (26) in. respectively from each end, and the remaining clips approximately four (4) ft. apart.

(j) Where radial arm clips are usd combination bar

stops and guides shall be provided for each ten (10) ft. of bar (equally spaced), and not less than two (2) such stops on one bar.

(k) Bars shall be mounted substantially and operated close to head of rail in a plane inclined toward the center of track.

(l) Bars shall rise a minimum of three-quarters (¾) in. above top of rail during the locking and unlocking of the switch and shall rest one-quarter (¼) in. below top of rail when lever movement is completed.

(m) Where rocking shafts are used, they shall be made of two (2) in. rolled steel with movable bearings and crank arms. Arms shall be............iron and nine (9) inches center to center. The bearings shall be securely bolted to ties with four (4) three-quarter (¾) in. bolts. The maximum spacing of supports shall be six (6) ft. centers.

(n) Detector bar fittings shall be Railway Signal Association Standard.

37. Adjustments.

(a) Open turnbuckles shall be placed in each pipe line as follows: One for each facing point lock, switch and lock movement, pipe connected high home, dwarf, or pot signal; bridge lock and couplers, located as near to the last operated unit as it is possible to get them, without having them directly under the rails, guardrails, frogs, switches or bridge guards.

(b) Open turnbuckles shall be made of............iron, with right and left hand thread, capable of giving an adjustment of not less than six (6) in., and provided with hexagon end shanks, which shall be the same size as the outside diameter of the one and one-quarter (1¼) in. standard jamb nut. Threaded rods shall be made of one and eleven thirty-seconds (1 11/32) in. wrought iron, provided with standard tang ends, threads and couplings.

(c) Wire lines for wire connected distant signals shall be provided with two (2) adjusting screws for each wire, one in the tower, and one at base of signal pole.

(d) Wire lines for wire connected dwarf signals shall be provided with one (1) adjusting screw for each wire and shall be placed in the tower.

(e) Wire adjusting screws shall be made of wrought iron not less than one-half (½) in. diameter with right and left hand thread, and shall be capable of giving an adjustment of twelve (12) in.

(f) Switches, derails, movable wing and point frogs shall be provided with special switch adjustment fastened to the head rod.

(g) Switches, movable wing and point frogs, and split point derails shall open not less than .... in.

38. **Signals.**

(a) General.—All signals shall be of the semaphore type with arm travel............degrees in the............right hand quadrant.

(b) Not more than one arm shall be placed on a dwarf signal post.

(c) Not more than three arms shall be placed on a high signal post, bridge, or bracket doll.

(a) Location.—The general type of signals are shown in the Railway Signal Association symbols and the location of signals shown shall be in accordance with scale plan No. ...., dated............ revised............

(b) All signal posts shall be on the right of the track governed, and adjacent thereto when possible.

(c) The arms shall be at right angles to the track governed on tangents, and at right angles to one thousand (1000) ft. chord on curves, or the total chord if curve is less than one thousand (1000) ft. long.

(d) Signals placed between tracks on tangents shall be set so that the center of post shall be midway between tracks. Signals placed between tracks on curves shall be set off the center line between tracks and towards the center of the curve two and one-half (2½) in. for each one (1) in. elevation in the outside of the curve.

(e) The balance levers on wire connected high signals located between tracks shall be set parallel to tracks.

(f) The contractor shall notify purchaser if tracks are less than .... ft. center to center for high signals, and .... ft. center to center for dwarf signals, which are shown between tracks or if any signals are shown within fouling limits.

(g) Outside of tracks, dwarf signal posts shall be placed .... ft. from nearest rail, high signal posts .... ft. and bracket posts .... ft.

(h) Base of dwarf signals shall be two (2) in. below base of rail. Base of high signals shall be .... in. below base of rail.

39. **Dwarf Signals.**

(a) Dwarf signals shall be .... position of the .... type.

(b) Posts shall be made of wrought iron pipe .... in. in diameter .... ft. .... in. from base to center of bearing, and .... ft. .... in. from base to center of arms. Arms shall be flexible or hinged, of .... in. x .... in. x ....

in., placed so that outer end is .... in. from vertical line through center of shaft. Arms shall be fastened to arm casting by two (2) bolts .... x ...., ... in. center to center vertically.

(c) Arm casting shall be made of .... iron, capable of holding one (1) .... glass, one (1) .... glass, and one (1) .... glass, solid color. Each glass shall be .... in. in diameter x .... in. thick with centers .... in. from center of shaft. Back lights will .... be required.

(d) Back light castings shall be capable of holding one (1) .... glass, solid color. Glass shall be .... in. in diameter x .... in. thick.

(e) Semaphore shaft shall be made of cold rolled steel .... in. square.

(f) Base castings for dwarf signals shall be cored for .... bolts .... in. in diameter at a radius of .... in.

40. High Signals.

(a) High speed signals shall be .... position.

(b) Medium speed signals shall be .... position. Low speed signals shall be .... position.

40. High Signals—Continued.

(c) Straight pipe posts shall be made of six (6) in., five (5) in., and four (4) in. wrought iron pipe with water-tight joints, and the size, weight, and length of the wrought iron pipe shall be

Item.	Size.	Weight per ft.	Length.
Top section	4 in.	10.66	10 ft.
Second section	5 in.	14.56	10 ft.
Third section	6 in.	18.76	To meet specification as to length.

(d) The length of straight post shall be as follows:

One arm 24 ft. 6 in.

Two arm 31 ft.

Three arm 37 ft. 6 in.

(e) The spacing of arms shall be as follows: distance from top shaft to second shaft six (6) feet six (6) inches, and from second shaft to third shaft ten (10) feet.

(f) Posts shall be mounted in base costings. Base castings shall be cored for four (4) one (1) in. bolts at a radius of .... in.

(g) Center of arms shall be .... in. .... the center of shaft. Arms shall be made of ...., ... in. x .... in. from vertical line through center of shaft, and shall be fastened by .... bolts

.... in. x .... in. spaced .... in center to center vertically and .... in. center to center horizontally.

(h) Arm castings shall be made of ...., capable of holding one .... glass, one .... glass, and one .... glass, solid color. Each glass shall be .... in. in diameter x .... in. thick, with centers .... in. from center of shaft. Back lights will .... be required.

(i) Back light castings shall be capable of holding one .... glass, solid color. Glass shall be .... in. in diameter x .... in. thick.

41. Bridge and Bracket Signals.

(a) All bridge and bracket dolls shall be made of four (4) in. pipe, mounted in .... base castings. Base castings shall be cored for four (4) bolts one (1) in. in diameter at a radius of .... in.

(b) Top of cross-trees shall be .... ft. .... in. above base of bracket post.

(c) Bracket post shall be made of nine (9) in. and eight (8) in. wrought iron pipe with water-tight joints mounted in .... base castings. Base casting shall be cored for four (4) bolts one and one-half (1½) in. diameter at a radius of .... in.

(d) Bridge dolls shall be located on .... chord of bridge.

(e) All signals, fittings, and glass shall be Railway Signal Association Standard.

42. Wire Lines.

(a) Two wires shall be used for operating each wire connected signal; the normal operating wire shall have two (2) in. more stroke than the reverse oprating wire.

(b) Wire lines shall be carried in wire carriers placed not more than twenty-one (21) ft. apart. Where wire lines run next to pipe lines, the wire carriers shall be attached to the pipe carrier foundations.

(c) Where wire carriers are attached to independent foundations, they shall be placed not less than six (6) ft. from gage of nearest rail where practicable.

(d) Where wire lines lead around curves the carriers shall be placed at the proper angle to prevent wire leaving groove of pulley.

(e) Turns in wire lines shall be made around chain wheels with a continuous piece of chain not less than four (4) ft. in length.

(f) Where specified on plans, wires shall be run inside of three-eighth (⅜) in. galvanized iron pipe under tracks,

roads, platforms, etc., provided at each end with a stuffing box attached to the pipe; stuffing boxes shall be provided with oil inlet.

43. Wire.

Signal wire shall be hard drawn, galvanized steel No. 8 B. W. G. (.165 in. in diameter). The wire shall be cylindrical, free from scales, inequalities, splices, and other defects. Each coil shall consist of one continuous wire not less than two thousand (2000) ft. in length and five feet in diameter. A single strand of this wire shall be capable of standing a load of two thousand (2000) lbs., and the elongation shall not exceed four (4) per cent. in a length of six (6) in. A specimen taken from a coil must be capable of standing four (4) close turns around its own diameter.

44. Chain Wheels.

(a) Chain wheels shall be made of malleable iron. Not more than two (2) shall be mounted in vertical line. The diameter of wheels shall be ten (10) in., except box wheels and wheels used in dwarf signal lines, which may have a minimum diameter of six (6) in.

(b) Stands for chain wheels shall have top, bottom, and intermediate supports. Distance between supports shall be .... in. and bottom of bottom support shall be .... in. above base. Wheels to be assembled with .... x .... in. steel pins. Bases shall be cored for four (4) three-quarter (¾) in. bolts .... x .... in. centers.

45. Wire Carriers.

Sheaves for wire carriers shall be two (2) in. in diameter over all and shall be made up in two (2), four (4) and six (6) ways, with no more than two (2) sheaves in vertical line. Stands shall be drilled for bearings .... in., and .... in. above base of bearing. Bearing of sheaves shall be supported by .... sheaves, and stands shall be made of malleable iron, and shall be secured to foundation with two (2) one and one-half (1½) in. number fourteen (14) screw.

46. Wire Eyes.

Standard one and one-half (1½) in. galvanized wire eyes shall be used in making all wire connections.

47. Split Links.

Split links shall have three-quarter (¾) by one and five-eighth (1⅝) in. inside dimensions and be made of five-sixteenth (5/16) in. galvanized steel. After connections are made points shall be closed.

48. Chain.

(a) All signal chain shall be made of one-quarter (¼)

in. diameter .... iron, and shall have a maximum of fourteen (14) links to the foot. The inside dimensions of the links shall be thirteen-sixteenths by one and three-eighths (13/16x1⅜) in.

(b) All signal chain shall withstand a breaking test of three thousand (3000) lbs., and the elongation shall not exceed ten (10) per cent. Test to be made with piece of chain twelve (12) ft. long, which shall show no deformation after test. Any link showing imperfection under proof test of twelve hundred (1200) lbs. shall be replaced before the chain will be accepted.

49. Lamps.

Lamps shall be Railway Signal Association Standard and shall be furnished by ....

50. Pins.

(a) All pins shall be made of steel with a permissible variance of .002 in. under size.

(b) Center pins for cranks, compensators, and switch and lock movements shall be interchangeable, and shall be one and one-quarter (1¼) in. by .... in., flattened at lower end to enter an oblong hole in the stands to prevent turning, with a groove in upper end so that they can be easily removed, and cotter pin holes shall be large enough to prevent shearing strain on one-quarter (¼) in. cotter.

(c) Connecting pins for cranks, compensators, machine tail levers, bolt locks, switches, pipe connected levers, etc., shall be seven-eighths by two and three-eighths (⅞x2⅜) in. under head drilled for three-sixteenth (3/16) in. cotter and two and one-eighth (2⅛) in. from under side of head, and heads of all connecting pins shall be either square or hexagon.

51. Bolts, Screws and Washers.

(a) All bolts, tap bolts, set screws, and machine screws shall have United States standard screw threads, nuts and heads.

(b) All nuts, bolt heads, tap bolts and set screws in connection with the machine shall have hexagon heads, and all other nuts, bolt heads, tap bolts, set screws, etc., shall have square heads.

(c) All lag screws shall be standard with gimlet points and square heads. They shall be screwed their entire length in holes previously filled with oil, and holes shall be bored small enough to provide full thread.

(d) Flat cut washers shall be used under bolt heads, nuts and heads of lag screws where they come in contact with wood.

52. Shore Foundations.

(a) Pipe carrier foundation shall consist of cast iron

piers, and wood or iron tops and bottoms as specified, or of concrete.

(b) Cast iron pipe carrier foundation piers shall be two (2) ft. five and one-half (5½) in. long, cored at top for two (2) one-half (½) in. bolts, spaced five and one-half (5½) in. between centers, cored at bottom for one (1) one-half (½) in. bolt one and one-quarter (1¼) in. from center line, and the average weight of piers shall be not less than twenty-two (22) lbs.

(c) Wood pipe carrier foundation tops and bottoms shall be made of two and three-quarter by seven and three-quarter (2¾x7¾) in. yellow pine lumber, dressed four (4) sides.

(d) Foundation for one (1) one (1) way pipe carrier in main pipe line shall be seventeen and one-half (17½) in. long and two and three-quarters (2¾) in. shall be added for each additional pipe carrier.

(e) Foundations used for one way pipe carriers in transverse pipe lines shall be twelve (12) in. long.

(f) Pipe carrier foundation tops shall be bored at each end for two (2) one-half (½) in. bolts one and one-half (1½) in. from end to center and five and one-half (5½) in. between centers. Pipe carrier foundation bottoms shall be bored at each end for one (1) one-half (½) in. bolt three (3) in. from end and one and one-quarter (1¼) in. from center line.

(g) Two (2) cast iron piers shall be used for each pipe carrier foundation up to forty-five (45) in. long, and one additional pier shall be provided for each additional thirty-six (36) in. or fraction thereof, and intermediate piers shall be inverted.

(h) Pipe carrier foundation tops and bottoms shall be fastened to piers with one-half by four (½x4) in. bolts.

53. Concrete Foundations.

(a) Cranks, compensators and bolt locks shall be fastened to iron piers arranged with slot for three-quarter (¾) in. bolts, and set in concrete. Plank to hold dwarf signals, deflecting bars, wheels, etc., shall be four by twelve (4x12) in. yellow pine, dressed two (2) sides, and fastened in a similar manner.

(b) All foundations shall be so constructed that apparatus can be removed without disturbing the foundations.

(c) Foundations for straight signal post shall consist of four (4) one (1) in. by three (3) ft. bolts set to templet in concrete.

(d) Foundation for bracket signals shall consist of four (4) one and one-half in. by .... ft. (1½ in. x .... ft.) bolts set to templet in concrete.

(e) All concrete foundations shall be set parallel to track.

(f) Dimensions of concrete foundations shall be as follows:

	Top.	Base.	Depth.
Cranks	20x18 in.	36x34 in.	36 in.
Compensators	34x18 in.	50x34 in.	36 in.
Two way chain wheels ..	22x18 in.	38x34 in.	36 in.
Dwarf signal	30x16 in.	30x16 in.	36 in.
Straight post signal.....	26x26 in.	36x36 in.	4 ft.
Bracket signal	38x38 in.	48x48 in.	5 ft.

(g) Concrete foundations shall stand until properly set before any apparatus is connected thereto.

(h) All foundations shall be rigid, level, and in perfect line.

(i) Wooden stakes for wire lines shall be three by four inches by five feet (3 in. by 4 in. x 5 ft.) with seven (7) in. point.

Note.—The plans and specifications for concrete foundations are adaptable to solid grounds. The Contractor is expected to use his best judgment as to the proper size and depth; and he will be governed by nature of ground.

54. Concrete.

(a) Concrete shall be made of one part Portland cement, three parts sand, six parts of broken stone and water to make proper consistency.

(b) The outer exposed face to a thickness of one (1) in. shall consist of one part of Portland cement, one and one-half (1½) part sand, deposited simultaneously with the interior mass. The top surface shall be floated and rubbed smooth by hand and true to grade and line.

55. Painting.

(a) General.—All material shall be pure and the quality of paint mixed shall be such as will permit of the application herein specified.

(b) Cleaning.—Surfaces covered with rust, grease, dirt or other foreign substances shall be thoroughly cleaned before paint or oil is applied.

(c) Application.—General. Paint shall not be applied to outside surfaces in freezing weather or to wet surfaces until they are thoroughly dried.

(d) Pigment finishing coats shall be sufficient body to form an opaque coating.

(e) Finishing coats shall not be applied until after the expiration of forty-eight (48) hours after the previous coating has been applied.

(f) All priming coats shall be applied as soon as is consistent with the progress of the work.

(g) All second coats shall be applied in sufficient time for the third coat to be applied and dry when the plant is completed.

(h) All iron work, except machine, tie plates, and iron foundation piers, shall be painted one coat of red lead and raw linseed oil, and two (2) finishing coats.

(i) The following specific finishing coats shall be used:

	Kind of paint.	Color.
Signal bridges and brackets....	....	....
Signal masts	....	....
All connections	....	....

(j) Machine.—The machine shall be painted one priming coat and one finishing coat of black jàpan from top of latch shoes to foundation supports.

(k) The levers shall be painted one priming coat and two finishing coats, as follows:

Lock levers, blue.

Switch levers, black.

Switch and lock levers, black and blue. Bottom half black and top half blue.

Distant signal levers, lawn green or lemon-yellow.

Home signal levers, vermillion.

Spare levers, white.

(l) The unfinished part of latch handle shall be painted same color as lever.

(m) All painted parts of machine above the floor shall have one coat of outside finishing varnish. The finished parts of the machine shall not be painted. All machine finished metal shall be slushed in white lead and linseed oil, except locking, which shall be coated with vaseline before being shipped.

(n) All chain and other iron work, not machine finished, shall be dipped in oil before being shipped.

(o) Wood Work.—Exposed wood work shall be given one priming coat and finishing coats as follows:

	Kind paint.	Color.	Number coats.
Home signal blades........	......	......	......
Dwarf signal blades.......	......	......	......
Distant signal blades......	......	......	......
Foundation tops and bottoms	......	......	......

(o) Building.—Signal stations, if built of wood, shall receive one priming coat and two finishing coats as specified below.

(q) The priming coat shall consist of yellow ochre, and, when thoroughly dry, two coats of pure lead and oil, in the following tints:

....

....

Prepared paints manufactured by...........................

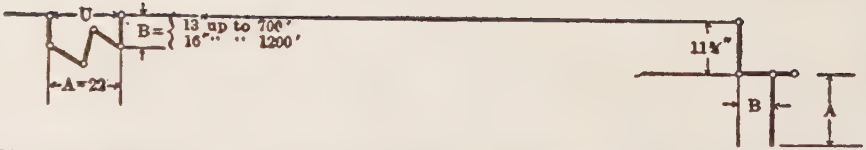
....

....

will be accepted.

56. Boxing.

Where boxing is specified, it shall be made of two by eight (2x8) in. lumber, dressed on one side. If bottom in boxing is specified, it shall be made of one (1) in.......... rough lumber. Where boxing is required through highways, the sides shall be made of three by six (3x6) in. and three by ten (3x10) in. .... lumber and shall be spiked to the foundation tops. Four by twelve (4x12) in. .... lumber shall be used for the tops and it shall be cut diagonally, and not nailed to the sides.



Values of "U" are based on .08 of an inch as coefficient of expansion for an increase of 10° F. for each 100' of line, and the nearest 1/16" is given.

Values of spacing "U" for given temperature and length of lines to be compensated and table of equivalent lengths to be used in compensating pipe lines when crank arms are of unequal lengths.

Temp. F°	LENGTH OF LINES COMPENSATED IN FEET.											
	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200
110°	21½"	21"	20⅝"	20"	19⅝"	19"	18⅝"	18"	17½"	17"	16⅝"	16"
90°	21 11/16"	21⅜"	21"	20 11/16"	20⅜"	20"	19 11/16"	19⅜"	19"	18 11/16"	18½"	18⅛"
70°	21 13/16"	21 11/16"	21 9/16"	21⅜"	21 3/16"	21"	20⅞"	20 11/16"	20½"	20⅜"	20¼"	20⅛"
50°	MEAN TEMPERATURE U=A=22"											
30°	22 3/16"	22 5/16"	22½"	22⅝"	22 13/16"	23"	23 3/16"	23 5/16"	23½"	23⅝"	23¾"	23 15/16"
10°	22 5/16"	22⅝"	23"	23 5/16"	23⅝"	23 15/16"	24¼"	24 9/16"	24⅞"	25 3/16"	25½"	25⅞"
0°	22 7/16"	22 13/16"	23¼"	23⅝"	24 1/16"	24 7/16"	24 13/16"	25¼"	25 11/16"	26⅛"	26⅓"	26 13/16"
−10°	22½"	23"	23⅜"	24"	24⅜"	25"	25⅜"	26"	26⅜"	27"	27⅓"	28"

"A" Length in Feet.	EQUIVALENT FOR "A" FOR VARIOUS LENGTHS OF "B."											
	B-7"	B-7½"	B-8"	B-8½"	B-9"	B-9½"	B-10"					
25	42	39	37	35	33	31	29	....	....	....	....	....
50	84	78	73	69	65	62	59	....	....	....	....	....
75	126	117	110	104	98	93	88	....	....	....	....	....
100	168	157	147	138	130	124	117	....	....	....	....	....
150	252	235	220	207	196	185	176	....	....	....	....	....
200	336	313	294	276	261	247	235	....	....	....	....	....
250	419	391	367	345	326	309	294	....	....	....	....	....
300	503	470	441	415	391	371	352	....	....	....	....	....
350	587	548	514	484	457	433	411	....	....	....	....	....

NOTE.—Since the mean temperature varies, it must be taken for the latitude where the work is done.

SPECIFICATIONS FOR POWER INTERLOCKING.

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GENERAL.

1. Specifications.

Adherence.—All the work herein outlined is to be done in strict accordance with the specifications, the accompanying plans and such instructions as may be given from time to time by the purchaser.

Spirit.—The nature and spirit of these specifications are to provide for the work herein enumerated to be fully completed in every detail for the purpose designed; and it is hereby understood that the contractor in accepting the contract agrees to furnish any and everything obviously necessary for such construction.

Special Work.—The purchaser will furnish herewith description and drawings of all special work.

Copies.—Duplicate copies of these specifications will be furnished by the purchaser with request for tender.

2. Drawings.

Preliminary.—The purchaser will furnish with each copy of the specifications copies of all drawings indicating the work to be performed.

The contractor shall examine these drawings, call the purchaser's attention to any apparent errors and ascertain the purchaser's wishes regarding the same before submitting a tender.

Final.—After the contract has been awarded, the contractor shall submit three (3) sets of the drawings showing

proposed arrangement or construction, which require the purchaser's approval, one set of which will be approved and promptly returned. Should changes in these drawings be necessary to meet the requirements of the spcifications, one set will be promptly returned with such changes indicated in writing, and the contractor may proceed with the work when such corrections have been made.

The contractor shall furnish four (4) sets of working drawings for the purchaser's files and upon request two (2) additional sets for the file of each other interested company.

Suitable framed manipulation chart and track diagram shall be furnished in place by the ....

3. **Supervision.**

Supervision.—All work shall be under the supervision of the purchaser's accredited representative hereinafter referred to as the supervisor.

*Foreman.—The foreman of installation, and his men, shall be satisfactory to the supervisor.

Instructions.—The foreman of installation shall receive and act upon all instructions given by the supervisor in writing, which do not involve additional expense to the contractor.

Inspection.—All materials and workmanship will be inspected thoroughly and carefully, and the contractor will be held at all times to the spirit of the specifications.

The supervisor shall be given free access to all parts of the work during the process of construction.

The purchaser will make a final inspection and tests within three (3) days after the completion of the work. Any defects or omissions noted during this inspection shall be made good by the contractor without extra charge before the work will be accepted and paid for in full.

Defective work.—The contractor, upon being so directed by the purchaser, shall remove, rebuild or make good, without charge, any defective work.

4. **Alterations.**

Specifications.—The purchaser reserves the right to make changes in plans and specifications. All such changes shall be handled in the same manner as the originals.

Extras.—Alterations involving an increase in cost of the amount of material to be furnished, or an increase in cost of work to be performed, shall be classed as extras.

Credits.—Alterations involving a decrease in cost of the amount of material to be furnished, or a decrease in cost of work to be performed, shall be classed as credits.

Compensation.—No compensation shall be allowed for extras or credits unless agreed to in writing.

5. Permits.

The purchaser will furnish all necessary permits. Work requiring permits shall not be performed until same have been provided.

6. Accidents.

Precaution.—The contractor shall place sufficient and proper guards for the prevention of accidents and shall put up and maintain at night suitable and sufficient lights, except as specified in Article 16.

Responsibility.—The contractor shall save the purchaser harmless and relieve him from all responsibility for any damage, injury or loss suffered by any person or persons in the employ of the contractor while such person or persons are engaged in the construction of interlocking, unless such damage, injury or loss is caused by the negligence of the purchaser.

7. Payments.

First Payment.—The purchaser will pay .... per cent of the contract price upon receipt of the material on the site of the work.

Second Payment.—The plan will be accepted and remaining .... per cent of the contract price will be paid within thirty (30) days after completion in conformity with the plans and specifications.

Extras.—Payments of extras involving additional compensation will be made in the same manner as prescribed for the contract price.

Credits involving a reduction in compensation will be reduced from the contract price.

8. Contract.

As soon as possible after the award is made, the contract, in accordance with the accompanying form, will be presented in duplicate to the contractor for his signature, after which both copies will be signed by the purchaser and one of them will be returned to the said contractor.

DETAIL.

10. Intent.

The intent of this specification is to clearly describe all of the material and labor required for and the results to be obtained by the complete installation of an electrically operated interlocking plant at .... on the lines of the .... R. R., as shown in the plans and supplementary data hereto attached.

Results.—Note.—This space is provided for a complete general description of the plant and all its adjuncts and of the operating results to be obtained therefrom.

11. Supplementary Data.

Practice.—The contractor's recognized best practice shall govern, except as herein otherwise provided.

The plans, drawings and detail specifications attached to and forming a part of these specifications are:

....

....

....

....

....

12. Material and Workmanship.

When it is necessary or desirable to use apparatus not heretofore in use, the contractor shall submit drawings of the same with his proposal and the acceptance of such proposal shall constitute acceptance of such new devices.

All material and workmanship shall be first-class in every respect.

The contractor shall furnish for replacement, free of cost, f. o. b. works, any apparatus or material of his own manufacture, or furnished on his specification which, when used for its intended purpose, shall prove defective within a period of one year after having been placed in service. Defective material will be returned upon written request and at the expense of the contractor.

The contractor's standard apparatus shall be used, except as herein otherwise specified.

Electric apparatus shall withstand an insulation test at the works of three thousand (3,000) volts A. C. applied for one minute.

All magnets and solenoids shall be plainly marked with their resistance and the size of wire with which they are wound.

Field coils of motors and all other magnet windings of mechanism shall be securely held to prevent vibration.

Note.—It is recommended that all windings for apparatus for electric interlocking shall be treated by a thorough impregnation process to resist moisture and improve the insulation.

13. Transportation.

The purchaser will .... furnish transportation for the men engaged in, and necessary tools and material required for, the installation of the plant over the following railway lines:

....

....

....

Shipment and Handing.—Tools and material are to be shipped
To ....
Care of ....
At ....
Via ....
Marked ....
Freight prepaid to..

The purchaser will unload and properly house only such material as arrives in advance of the contractor's men.

The use of the following cars will be permitted under the restrictions of Articles Nos. 6 and 16, unless otherwise indicated in this paragraph:

	Number.	Furnished by
Motor cars	....	....
Velocipede cars	....	....
Handcars	....	....
Pushcars	....	....

When the contractor is not permitted to use handcars or pushcars, the purchaser will, at his own expense, distribute all material to the point of use upon receipt of notification from and under supervision of contractor's foreman.

The contractor shall call upon the purchaser for the required number of cars for the return of tools and unused material, and same will be furnished in .... days, after which time the purchaser will, at its own expense, care for and load all tools and material.

14. Track Work.

The purchaser will furnish:

All switches, derails and movable point frogs in place adjusted to the required throw.

All ties in place required for the support of the apparatus.

All rail braces and will install all except those located on the plates furnished by the contractor.

All insulated rail joints in place.

The purchaser will move all ties which interfere with installation of the interlocking apparatus or connections.

The purchaser will remove all guard rail clamps, rail braces, anti-creepers and lips and otherwise prepare the rail for installation of detector bars.

The purchaser will remove and replace all switch and tie rods (other than front rods on interlocked switches) requiring a change in location, the application of insulation, adjustment brackets or other alterations.

15. Obstacles.

The purchaser will do all preliminary grading, provide adequate drainage and blast and remove all solid rock that will

interfere with the placing of the interlocking apparatus or connections.

The purchaser will furnish all extra labor and material required to place apparatus or connections in or under all platforms, roadways or walks, the location and construction of which are not herein specified.

16. **Traffic.**

The contractor shall not unnecessarily delay or interfere with traffic. When it becomes necessary for contractor to perform any work which may interfere with or endanger traffic, the contractor shall notify the purchaser and shall not proceed with said work until traffic is protected.

The purchaser will promptly arrange to protect traffic upon request of contractor.

17. **Completion.**

The contractor shall notify the purchaser, in writing, not less than seven (7) days before the plant will be ready for service.

The contractor shall put the plant in service under the supervision of the purchaser, and shall leave .... competent men on duty for .... hours thereafter.

The purchaser will maintain and operate the plant as soon as it is put in service.

The purchaser will put the plant in service, providing this cannot be done within three (3) days after the completion of the contractor's work.

The contractor shall remove and dispose of all excess earth and all refuse made by the contractor's men or shall load on cars, where disposal cannot be made on right-of-way within interlocking limits.

18. **Provided by Purchaser.**

a ....
b ....
c ....
d ....
e ....

Note.—Items to be provided by purchaser should be assembled and filled in at this point.

19. **Tenders.**

Sealed tenders for the work covered by these specifications will be received:

by ....
at ....
up to ...... hour of the ...... day of ...... month ...... of ...... at which time and place said tenders will be opened. Bidders are invited to be present.

Tenders shall be divided as follows:

Note.—This space is provided for a complete description of the manner in which the tenders are to be divided for the different portions of the work.

a ....

b ....

c ....

d ....

The purchaser reserves the right to reject any and all bids.

20. **Tower.**

A .... building for tower .... stories high, and ....x........, inside dimensions, shall be built by the .... in accordance with specifications and drawings .... for building and drawings .... for frame.

Note.—In erecting a wooden tower provision should be made for leadout wires in an asbestos lined or ...... lined chase, accessible for its entire length. Not less than fifty (50) per cent of the capacity of the chase will remain free for the further installation of wires.

When fireproof towers are erected a special chase for entrance of wires should be provided.

21. **Power House.**

A .... building for power house .... stories high and ....x........, inside dimensions, shall be built by the .... in accordance with specifications and drawings .... for building and drawings .... for frame.

22. **Foundations.**

.... foundations for the buildings shall be built by the .... in accordance with specifications and drawings ....

23. **Gasoline Tanks.**

Housing for gasoline tank as per drawing ...., located not more than .... ft. from the power house, will be built by ....

24. **Lighting.**

The number, kind, size and distribution of electric lamps shall be as follows:

Room.	Number.	Candle-power.	Location and Description.
Operating Room			
Lower Story			
Battery Room			
Generator Room			
Special			

Lights shall be controlled by switches located as follows:
Number.
..................Operating Room Lamps..................
..................Lower Story Lamps..................
..................Battery Room Lamps..................
..................Generator Room Lamps..................
..................Special Lamps ....

Fixtures for electric lamps will........be required. When required they will be provided by purchaser and installed by contractor.

The electric lights and accessories shall be acceptable to and installed under the rules of the National Board of Fire Underwriters and the attached requirements of the local authorities.

25. Appurtenances.

Except as otherwise specified, all tools, fixtures for buildings, and supplies required for the operation of the plant will be furnished by purchaser.

POWER PLANT.

30. Composition and Location.

The power plant shall consist of:
..................engine ....connected to
..................motor ....connected to
..................generator ....
..................transformer, together with..................
mercury arc rectifier..................charging rheostat
.... operating switchboard..................
motor starting panel..................and ....
storage batteries, each composed of..................cells, all in accordance with detailed specifications herein and shall be installed by the .... in the locations provided by the..................

31. Engine.

A .... cylinder .... cycle
Vertical)
Horizontal) ....engine of..........brake H. P.
Turbine)
manufactured by............installed by the............
shall be furnished on a..............foundation to be furnished in place by the...........built in accordance with the standard specifications of the.............and plans of the manufacturer of the engine dated..................

A complete set of wrenches shall be furnished.

Note.—This space is provided for detailed specifications of engine to be used.

(a) ....
(b) ....
(c) ....
(d) ....
(e) ....

Note.—The engine should be of such type as to be easily accessible for attention to bearings, adjusting and cleaning.

Note.—For power interlocking work, as a simple and desirable method of operation, a constant rate of charging for the storage battery is taken as the basis for the establishment of the recommended capacity ratios between the battery, the generator and the engine.

GASOLINE ENGINE SPECIFICATIONS.

The recommended brake horse power of the gasoline engine shall be not less than one and three-quarters times the kilowatt capacity of the generator at the maximum voltage and the eight hour charging rate.

The engine shall run without injurious vibration and shall operate continuously at manufacturer's specified capacity for a period of sixteen (16) hours without injurious heating in any part.

Regulation in speed shall be within three (3) per cent from no load to full load and the regulation as recorded on the voltmeter for a given current shall not vary more than two (2) per cent between impulses.

Electrodes on the engine for electric ignition shall be tipped with platinum or an equally serviceable material.

The manufacturer's standard exhaust muffler shall be provided.

The engine and accessories shall be acceptable to and installed under the rules of the National Board of Fire Underwriters and the attached requirements of the local authorities.

Engines of twenty-five (25) H. P. or less shall not exceed a speed of four hundred revolutions per minute.

A gasoline tank of..............gallons capacity shall be furnished. Both fuel and cooling tanks shall be made of iron or steel with brazed or riveted seams. All tanks shall be dipped in the galvanizing kettle after they are put together.

Sufficient piping shall be furnished to locate the gasoline tank................ft. from the engine.

Unions in all piping shall be equipped with ground brass seats.

Note.—For tanks both for fuel and water it is recommended that selection shall be made, when practicable, from the following table:

GASOLINE TANKS FOR RAILROAD WORK.

Capacity. Gallons	Inches in Diameter.	Inches in Length.	Gage of Metal.	
			Head.	Body.
66	18	68	No. 14	No. 16
120	24	66	No. 12	No. 14
500	36	120	No. 10	No. 12

As a guide in ordering tanks it is good practice to consider that it will require one-tenth (1/10) of a gallon of gasoline per H. P. hour for gasoline engines.

For cooling the minimum of free running water should not be less than ten (10) gallons per H. P. hour and for the circulation tank system not less than fifty (50) gallons per H. P.

Unless otherwise specified, an iron or a steel cooling tank of sufficient capacity for a continuous run of ten hours on one filling, with connections and removable cover, shall be furnished. Connections between engine and tank shall be arranged for convenient and complete drainage of the cooling system, for independent drainage of the engine and tank, and to conduct all waste water and steam to the outside of the building.

32. Generator.

The generator shall be shunt wound, self-excited, shall have self-oiling bearings, carbon brushes, rheostat, and when belt connected, a belt tightener, sub-base and pulley.

The normal or rated speed shall not exceed 1,500 R. P. M., except when direct connected to an A. C. motor or steam turbine.

The generator shall have a continuous current capacity equal to the eight hour rate (......Amp.) of the battery, at a voltage equal to the maximum voltage (.... volts) of the battery on charge, without a rise in temperature in any part exceeding 40 degrees C. (72 degrees F.), above the temperature of the surrounding atmosphere. It shall be so wound that its voltage at the continuous current rating given above may be varied by means of a field rheostat from the minimum to the maximum charging voltage of the battery. The generator shall be capable of supplying for four hours a current output twenty-five (25) per cent in excess of the continuous current capacity referred to above without a rise in temperature in any part exceeding 50 degrees C. (90 degrees F.) above the temperature of the surrounding atmosphere.

It is understood that the temperature of the surrounding atmosphere is to be based on 25 degrees C. (77 degrees F.), but should the temperature vary from this, corrections shall be made in accordance with the recommendations of the American Institute of Electrical Engineers.

The current output of the minimum allowable generator shall be that required for the operation of two switches simultaneously.

With the brushes in a fixed position, the generator shall be practically sparkless under all operating conditions as outlined above.

Note.—These generator specifications will fix a machine which in normal power interlocking service will have an ample overload capacity to meet general requirements.

33. Motor.

The motor shall be..........H. P., with a rated speed not to exceed 1,500 R. P. M., if direct current, or 1,800 R. P. M., if alternating current, and shall have automatic regulation to within 20 per cent when operating on........to........ volts, D. C., or on.........to.........volts.........cycles, ...phase A. C., shall conform to generator specifications regarding heating, sparking and insulation, and shall be furnished with a starting panel.

34. Motor Generator.

Motor generators shall be direct connected, mounted on a cast iron sub-base and shall conform to the specifications for motors and generators.

35. Transformers.

36. Storage Battery.

(1) The storage battery shall consist of..........cells A. H. capacity..........type at eight hour rate.......... with glass jars manufactured by......................or

(2) The storage battery shall consist of...........cells manufactured by...................of sufficient capacity to operate the interlocking plant, together with all accessories which obtain a current supply from the main battery, electric lighting...........included, for a period of...........days on one charge, on the basis of............lever movements and of lights burning..........hours per twenty-four hours.

Batteries up to four hundred A. H. capacity shall be placed in glass jars. All batteries shall be rated for an eight (8) hour discharge at 70 degrees F.

Note.—For a battery of a capacity greater than four hundred A. H., wooden tanks should be required and should be covered by special specifications.

Note.—It should be borne in mind both that the capacity of a storage cell decreases with a decrease in temperature and that the extent of such decrease should be obtained from

the manufacturer, and also that the number of days of excess capacity for the battery to be allowed should be stated and depends upon conditions of maintenance and operation, for example, frequency of visits of maintainer.

The cells shall be connected by lead covered bolts. Burnt connections shall be used when specified. The rows of cells shall be connected together by lead strips of as great a sectional area as the connections between cells, or by lead coated copper connections of equivalent carrying capacity. Such connections shall be considered a part of the battery.

A plan showing separate battery room shall be furnished the contractor.

The battery shall be installed with a minimum vertical clearance of thirty inches above the jars and so as to permit the removal of any element without disturbing its containing jar or adjacent cells. Unless otherwise specified, the battery shall be easily accessible from both sides for inspection and attention. Plates shall be arranged transversely with the rows.

The battery shall be provided with............sand trays which shall be so constructed as to prevent the leakage of sand to the lower cells.

The insulators supporting the sand trays shall rest on wooden racks treated with an acid-proof paint.

The racks shall be supplied in place by the............in accordance with the standard plans of the........, ... hydrometers and........extra jars shall be provided.

The initial charge of the battery shall be conducted by ....

The instructions of the manufacturer shall be followed during this initial charge and a copy of the readings which are taken during the charging period shall be sent to him.

The..................shall provide current at the proper voltage for the initial charge.

37. Switchboards.

General.—Switchboards shall be made of oil-finished slate not less than one (1) in. thick and free from metallic veins or flaws.

They shall be of ample size to accommodate all the instruments, switches, etc., required for the operation of the plant.

They shall be supported on substantial iron frames and mounted, when not more than twelve (12) in. wide, not less than fifteen (15) in. from the wall.

Note.—The distance between a switchboard and the wall depends on the width of the board and the voltage employed.

They shall be acceptable to and installed under the rules of the National Board of Fire Underwriters and the attached requirements of the local authorities.

The finish of all fittings on each switchboard shall be uniform where practicable.

All switches shall be substantially constructed and so mounted as to preserve their alignment.

Each switch shall be provided with a plate designating the circuit which it controls.

National Standard enclosed clip fuses of the required capacity shall be provided for all circuits not otherwise protected.

Power Board.—The power board shall be equipped with one..........ammeter and one.........voltmeter, ammeter to be arranged to show current in any circuit. The use of external multiple shunts will not be permitted.

Where duplicate charging sets are used a voltmeter switch shall be provided for connecting meter to either generator.

A no-load reverse-current circuit-breaker shall be provided in the battery charging circuit.

The generator field rheostat shall be mounted on ...... of board.

Motor Starting Panel.—Starting box for D. C. motors shall be designed to protect the motor from overload, both in starting and running positions, and in case of failure of the line voltage or opening of the field circuit shall return automatically to the "off" position.

The resistance shall be proportioned to start the motor without excessive rushes of current and without overheating.

The manufacturer's standard device shall be furnished for starting A. C. motors.

Operating Board.—The operating board shall be equipped with a..........ammeter, arranged to show current in the operating and also in auxiliary circuits when used. The use of external multiple shunts will not be permitted. When low voltage auxiliary circuits are used, the ammeter shall be provided with high and low reading scales.

The operating board shall be provided with one 2 candle power lamp for detecting grounds, and one 2 candle power lamp for illuminating ammeter scale.

Binding posts, with two nuts and two washers each, shall be provided on bottom of operating board, for all external connections.

(D. P.)
The operating board shall be provided with one
(S. P.)
knife switch and................the National Standard enclosed fuses for the control of each signal lighting circuit where same are required.

MACHINE.

40. Capacity.

The interlocking machine shall have:

..............levers for..............one-arm high signals.
..............levers for..............two-arm high signals.
..............levers for..............arm high signal.
..............levers for..............one-arm dwarf signal.
..............levers for..............two-arm dwarf signal.
..............levers for..............switches and derails.
..............levers for..............movable point frogs.
..............levers for..............crossing bars.
..............levers for..............lock levers.
..............levers for..............spare spaces.
......................................spare spaces.
......................................Total spaces.

41. Locking.

The machine shall be provided with mechanical locking of the preliminary type, so designed as to prevent the manipulation of levers for conflicting routes.

Space for one locking bar the full lentgh of the machine shall be provided in the locking bed for each spare space or spare lever. Locking shall be so arranged as to be easily accessible.

42. Levers.

Levers shall be numbered to correspond with attached plans. Normal and reverse latches shall be provided.

Lever handles shall be of purchaser's standard color as per following table:

Home signal levers, vermilion.
Distant signal levers, lawn green or lemon yellow.
Lock levers, blue.
All other levers, black.

43. Indication.

Each lever shall be provided with a device to insure correspondence in the movement of the lever and that of the unit controlled thereby before the release of the mechanical locking can be effected.

Levers shall be free to move between their indicating positions.

44. Terminal Board.

The machine shall be provided with a slate terminal board, having binding posts for making all connections leading from the machine, and fuses for the protection of the circuit for each operated unit.

45. Case.

The machine shall be enclosed in a case to prevent improper manipulation.

50. General.

All signals shall be of the iron pole and semaphore type with mechanism enclosed in iron case.

Signals shall conform as to location and dimensions to the Railway Signal Association standards.

All motors in place shall be of sufficient capacity and mechanism constructed to perform complete operation of a ninety (90) degree signal of Railway Signal Association standard, when not more than........ft. from interlocking machine, in not more than..........seconds with battery at ten (10) per cent below normal voltage.

The normal voltage of battery is one hundred and ten (110).

Note.—It is recommended that fair working conditions consist of a distance of thirty-five hundred (3500) ft. from interlocking machine and seven (7) seconds of time of complete operation.

51. Lanterns.

The purchaser's standard (oil) (convertible) lanterns, as manufactured by.............shall be furnished by...........

52. Arms and Spectacles.

High signal arms shall be..........ft. long, ...in. wide at outer end, and made of well seasoned clear white ash, or equally good material.

Dwarf signal arms shall be flexible or hinged, and........ in. long.

Painting of blades shall be as shown on Drawing No. ...., dated ...., attached.

The purchaser's standard signal spectacle castings shall be used, as shown on Drawing No. ...., dated ...., attached.

Roundels shall be solid color, one-fourth (¼) in. thick, and supplied as follows:

Caution, color ...., Dia..................in.
Stop, color ...., Dia..................in.
Proceed, color ...., Dia..................in.
Dwarf, color ...., Dia..................in.
Back, color ...., Dia..................in.

Color density of roundels shall be as per attached specifications of the purchaser, or shall be within the following limits:

....	....	Scale.
Color	Scale................	Scale.
Red	to.........	.........to.........
Green	to.........	.........to.........
Yellow	to.........	.........to.........
Blue	to.........	.........to.........
Purple	to.........	.........to.........

53. Foundations.

Foundations shall be made of concrete, and in general conform to the purchaser's standard, as shown on .... plan No. ...., dated ...., attached.

Dimensions of top of signal foundations shall be six (6) in. greater than dimensions of bottom of mechanism case or base of signal.

The minimum foundation shall have a top surface two and one-half (2½) ft. square, a bottom surface three and one-half (3½) ft. square, with a vertical height of four (4) ft.

Concrete shall be mixed in the following proportions:

....

....

....

Anchor bolts for high signals shall be one (1) in. in diameter and three (3) ft. long.

Anchor bolts for signal brackets shall be one and one-quarter (1¼) in. in diameter and four (4) ft. long.

Ladders shall be provided with .... foundations, as shown on Drawing No. ...., dated .... attached.

54. **Electric Lighting.**

Electric lighting of signals will .... be required.

Convertible lanterns shall be equipped with ...... candle power incandescent lamps and marine receptacles, in accordance with .... Drawing No. ...., dated .... attached, also with oil fonts and burners. .... extra incandescent lamps shall be furnished.

Electric lights on signals shall be arranged on .... circuits as follows:

(Distribution and grouping of lights for each circuit to be shown in this space.)

SWITCHES.

60. General.

Switch mechanism shall perform their normal operations in the following sequence:

1. Unlock switch.
2. Throw switch.
3. Lock switch.
4. Indicate.

All motors in place shall be of sufficient capacity and mechanisms constructed to perform complete operation of normal and reasonably free working switch in not more than four (4) seconds at a distance from interlocking machine of not more than .... ft., with battery at ten (10) per cent below normal voltage. The normal voltage of battery is 110.

Note.—It is recommended that fair working conditions

consist of a distance of one thousand (1,000) ft. from interlocking machine.

Mechanisms shall be so constructed and equipped that switch can be stopped or reversed at any point of movement by manipulation of lever controlling same.

Mechanism shall be equipped with an efficient friction clutch to prevent damage to same in case movement of switch is obstructed. If friction clutch fails to release motor, all parts of mechanism shall be strong enough to permit of stopping the switch at any point of its movement by introduction of an obstruction between point and stock rail without injury to any part.

Staggered locking shall be provided for the normal and reverse position of the points.

The hole or notch in lock rod shall be not more than one-sixteenth (1/16) in. larger than plunger measured in a horizontal line.

Note.—It is recommended as a safe and better method of operation that a rectangular lock rod be employed with a vertical looking face of a height as great as practicable. Consideration should be given to the substitution of better wearing and stronger materials for those at present employed in the locking edges and surfaces of the plunger and lock rod, and endeavor should also be made to, in the best practical way, secure as great an engaging area as possible when the lock rod is moved three-thirty-seconds (3/32) in. out of lock position.

Switch mechanism shall be protected by substantial iron covers fastened to ties or mechanism with wrought or malleable iron fastenings, in a manner to permit of convenient inspection of mechanism.

The location of switch operating mechanism shall be as shown on .... Plan No. ...., dated .... attached.

All parts of mechanisms and covers shall be placed outside of clearance limits, as shown on diagram on .... Plan No. ...., dated ...., attached.

61. Mechanical Connections.

The mechanical connections for switch mechanism shall be arranged in accordance with Contractor's standard practice, unless otherwise provided.

Strength of connections shall be such that switch points can be stopped by placing an obstruction between point and stock rail at any part of stroke without breaking or bending any such connections.

Both the operating rod and the lock rod shall be of suffi-

cient strength to alone and independently hold the switch points in position.

Connections shall be strong enough to prevent bending or breaking in case mechanism is operated when detector bar is engaged by wheels of a car or engine.

When either pipe, pipe joint material, pipe carriers, compensators, cranks or other such material are used in connections between movements and detector bars, such material shall conform to the Mechanical Interlocking Specifications of the Railway Signal Association.

All ties whose relative location affects the correct operation of mechanism shall be securely strapped together, as shown on Purchaser's Plan No. ...., dated ...., attached.

62. **Detector Bars.**

Bars shall be located as shown on .... Plan No. ...., dated ...., attached, unless otherwise specified.

Note.—Bars on curves should be located on inside, outside or both sides of curve, or as determined by local operating traffic conditions.

Detector bars shall be arranged to give fifty-three (53) ft. continuous protection for all switches, derails, movable wing and movable point frogs.

When used on outside of rail, detector bar shall be made of one-half by two and one-quarter (½x2¼) in. wrought iron or steel, and have one beveled edge, square ends and bolted joints. Full length bars shall be made up in eighteen (18) ft. sections.

Bars shall be drilled one (1) in. from bottom of bar to center of hole for three (3) one-half (½) in. countersunk head bolts or rivets. The first hole shall be one (1) in. from end to center and two (2) in. between centers of holes. Where splice plates are specified, they shall be made of wrought iron or steel one-half by two by twelve (½x2x12) in., rivetd at the end of bar with three (3) one-half by one and one-eighth (½x1⅛) in. countersunk head rivets and attached to intermediate adjacent sections by three (3) one-half by one and one-half (½x1½) in. countersunk head bolts, with nuts held in place by nut locks.

Driving pieces shall be made of wrought iron or steel arranged for one and one-quarter (1¼) in. jaw connections. The part where the jaw is connected shall be three-quarters by two by three (¾x2x3) in., and part riveted to bar shall be one-half by two by six (½x2x6) in., drilled for three (3) one-half (½) in. rivets, one (1) in. from end and two (2) in. between center of holes. Offset from bar to jaw connection shall be one and one-half (1½) in.

Driving pieces shall be placed midway between two (2) clips in space not occupied by joint, and the driving rod shall have not more than seven (7) ft. of its length unsupported.

Fifty-three (53) ft. bars shall be mounted on seventeen (17) .... type rail clips, and a proportionate number of clips shall be used for longer or shorter bars.

Centers of rail clips shall be placed eight (8) in. and twenty-six (26) in., respectively, from ends and the remaining clips approximately four (4) ft. apart.

Where radial arm clips are used combination bar stops and guides shall be provided for every ten (10) ft. of bar (equally spaced), and not less than two (2) such stops on one bar.

Bars shall be mounted substantially and operated close to head of rail in a plane inclined toward the center of track.

Bars shall rise a minimum of three-quarters (3/4) in. above top of rail at every point before the unlocking of the switch, and shall rest one-quarter (1/4) in. below top of rail when lever travel is completed.

Detector bars, when practicable, shall be so connected that the unlocking movement when switch is in the main line position shall be in the reverse direction to the facing movement of traffic over the points.

Where rocker shafts are used, they shall be made of two (2) in. square cold rolled steel with movable bearings and crank arms. Arms shall be .... iron and nine (9) in. center to center. The bearings shall be securely bolted to ties with four (4) three-quarter (3/4) in. bolts. The maximum spacing of supports shall be six (6) ft. centers.

Other detector bar fittings, where required, shall be Railway Signal Association Standard.

Detector Track Circuits.—Detector track circuits will .... be required in addition to
lieu of
detector bars.

When detector track circuits are required, they shall conform to the following specifications:

Note.—Detail specifications to be given here for results required of detector track circuits as to control of switches, etc.

....
....
....
....

Note.—Reference is made in Section 100 to various purposes to which such circuits may be applied.

63. **Switch Circuit Controllers.**

Circuit controllers of substantial construction and positive in action shall be provided for each switch mechanism, and shall be so constructed that they can be maintained to make or break circuit when switch point shall be moved from the closed position three-sixteenths (3/16) of an inch.

Operating rods of switch controllers shall be one (1) in. in diametr and adjustable, with a maximum distance apart of supports of three (3) ft.

Note.—Consideration should be given to the question of the connection of the circuit controllcr to the switch, as to whether one or both points shall be positively connected, and if but one point, which shall be selected. It is recommended that circuit controller be insulated from tie plate and switch point.

WIRE AND WIRING.

70. Specification.

All wire shall conform to the standard specifications of the Railway Signal Association.

71. Size.

All wires shall be of sufficient size to permit operation of switch and signal mechanism in accordance with previous specifications.

Rubber covered wire smaller than No. 14 B. & S. shall not be used.

Copper line wire smaller than No. 10 B. & S. shall not be used.

72. Tagging.

All wires shall be tagged at all junction boxes, switches, signals, relay boxes, arrester boxes and at all line wire connections.

All tags shall be made of vulcanized sheet fiber not less than one-sixteenth (1-16) in. thick, firmly attached to the wire by best quality tarred yacht marline one-sixteenth (1-16) in. in diameter.

The tag shall have a stamped imprint to show the functions of the wire.

73. Runs.

Wires shall be laid loosely in trunking without stretching or crowding.

All wires shall, as far as practicable, be continuous without joints or breaks between interlocking machine and the unit operated; joints when made shall be in junction boxes and only made on permission from Supervisor.

In submarine cable work spare wires up to twenty-five (25) per cent of the number in use shall be provided as specified. When spare wires are required in other than cable work the number and size shall be specified.

74. Common.

Unless otherwise specified, common wires shall be continuous without joints or breaks from interlocking machine to the limits of the interlocking plant.

Reductions in size of common wire and connections to pole lines shall be made in junction boxes.

All connections between branches and main common wires shall be made in junction boxes, with combination clamps and terminals mounted on slate bases.

But one unit shall be connected to one branch from the common wire.

No common wire shall be less than No. 12 B. & S. gage.

75. Joints.

Joints must be made as follows:

Braid shall be pulled back one (1) in. from end of rubber on each side of splice, and rubber cut with knife held at an angle of approximately thirty degrees with axis of wire, as one would sharpen a pencil.

After removing rubber, wire shall be thoroughly cleaned, care being taken to prevent injury from small cuts or nicks.

Wire, after being cleaned, will be twisted together in the form of a regular line wire splice, turns being spaced approximately one-sixty-fourth (1-64) in.

Joints shall then be soldered by pouring on, or dipping wire into, melted solder, a non-corrosive rosin flux being used. After soldering, joints shall be painted with .... insulating paint or with .... compound. Joints will then be covered with two layers of .... insulating tape between ends of braid, which tape shall be heated sufficiently to form a tight covering but not enough to injure the quality of the material. Coating of .... insulating paint or .... compound shall be put on over insulating tape and two layers of .... adhesive or friction tape shall be applied, after which the outside of joint is to be painted with .... insulating paint.

WIRE PROTECTION.

80. Trunking and Conduit.

Trunking, when on stakes above ground and running parallel with the track, shall not be placed nearer than six (6) ft. from the gage side of the nearest rail except by special permission.

Local conditions shall determine the height of trunking when above ground; in general, when trunking is run parallel with the tracks, bottom of trunking shall be placed approximately six (6) in. above the ground.

The location of the main runs of trunking is shown on Plan No. ......, dated ...., attached.

Note.—Permission should be obtained to place between tracks run of trunking parallel with the tracks.

Material.—All grooved trunking, built up trunking and all capping, as specified, shall be made in accordance with Railway Signal Association drawings for standard wood trunking, dated July 8, 1908.

Commercial sizes of lumber shall be used, finished on one side and two edges.

Where slight changes in dimensions of grooved or built up trunking are necessary, either due to failure of the commercial lumber to run to exact sizes or due to finishing of the surfaces, such changes shall be allowed for in the walls of groove, the groove remaining exact size throughout.

As specified, capping shall be securely fastened to trunking with..
gate hooks.
nails.

Note.—It is recommended that gate hooks be used on main runs of trunking and nails on cross leads.

Nails shall not be driven through the trunking from the inside of the groove nor shall they be driven into the groove from the inside.

Drainage of the trunking shall be provided as follows:
....
....
....

Inside corner of trunking, at turns, must be rounded to prevent insulation on wires being injured.

Not less than one-third (1/3) of the capacity of the groove shall remain free for the further installation of wires.

Surfaces of trunking that are to be painted shall be finished.

Treated trunking must be used when specified, and shall comply with the requirements as to treatment which are attached ....
....
....
....

When specified, the wires in the trunking shall be loosely bound and shall be so laid in pitch as to be practically free of contact with all walls of the trunking. Pitch as used must not crack at a temperature of .... degres F., and must not melt at a temperature of .... degrees F. It must neither contain any material nor be applied at a temperature which will injure the rubber insulation.

Boot-Legs.—Boot-legs for track connections shall be made according to .... Plan No. ...., dated ...., attached, and shall be securely fastened to the trunking not less than two (2) in. from base of rail, and shall not extend more than one (1) in. above base of rail.

Joints.—Except as otherwise shown in drawings which have been furnished, all joints in grooved trunking shall be lapped, the ends of trunking being beveled at an angle of forty-five (45) degrees.

When trunking is built up all joints shall be staggered.

All joints in capping shall be made at least one (1) ft. from joints in trunking.

81.—Supports.

Trunking above ground shall be supported on stakes placed not more than five (5) ft. centers.

Except as shown on attached drawings, stakes shall be made .... three (3) in. by four (4) in., or of equivalent circular section, and of sufficient length to allow them to be placed at least two (2) ft. in the ground. When, due to local requirements, such as contour of the ground or other physical conditions, stakes of a greater length than three (3) ft. six (6) in., or a greater cross-section than three (3) in. by four (4) in. will be necessary, information as to the number, length and cross-section of such will be furnished by the Purchaser to the Contractor.

All stakes supporting trunking shall be placed vertically and extend at least two (2) ft. below the surface of the ground, unless otherwise specified.

A piece of capping eight (8) in. long and the width of the trunking shall be placed between the trunking and each stake.

All joints in the bottom of the trunking shall be supported by stakes.

Where trunking exceeds a width of seven (7) in. a special arrangement consisting of (a double line of stakes—a single line of large) stakes shall be installed, or provision shall be made as follows...
....
....

82. Junction Boxes.

Location.—Junction boxes shall be located as shown on .... Plan No. ...., dated ...., attached (which also shows general runs of trunking), and at a height sufficient to allow terminals to be placed at least six (6) in. above top of trunking.

When so indicated on plan, junction boxes shall be supported in the same manner as the trunking.

Material.—Junction boxes shall be made of .... and so designed that terminals will be kept dry. Each junction box shall be fitted with a cover, hasp and staple suitable for the Purchaser's standard lock, No. ...., made by ....

Size.—Where ten (10) or less wires are used, junction boxes shall be sixteen (16) in. square by twenty (20) in. deep inside dimensions, and shall be increased six (6) in. in length for each ten (10) or fraction thereof additional connections made in the box.

83. Lightning Arresters.

Lightning arresters of .... design shall be used at all aerial line connections.

Lightning arresters shall be grounded through two (2) No. 8 B. & S. gage copper wires (insulated above ground), wrapped around and soldered to a galvanized iron ground rod not less than one (1) in. in diameter, driven eight (8) ft. into the ground.

Where such ground connection is not satisfactory the desired protection for each point shall be specified by the Purchaser and furnished in place by the ....

84. Fuses.

The necessary fuses to properly protect all apparatus and circuits shall be installed.

Double pole fuse cut-out shall be provided for each circuit on power board.

An additional double fuse cut-out shall be placed in storage battery leads as near as possible to battery terminals.

CIRCUITS.

90. General.

All circuits shall conform to the Contractor's recommended practice unless otherwise specified.

91. Signals.

All high and intermediate speed signals shall be so controlled by circuit breakers on all facing derail, switch and frog points over which they govern, that unless such points are in proper position and locked the signals will assume the stop position. Low speed signals shall be controlled by facing point derails in the same manner.

Each distant signal shall be controlled by circuit breakers on all signals, the indication of which it repeats, and so arranged that the circuit to the distant signal is broken unless all signals for the track governed are in proceed position.

All non-interlocked single main line switches, both ends of cross-over switches and siding derails between home and distant signals shall be protected by switch circuit controllers.

92. Switches.

The circuits for facing point derails shall be controlled by normally closed circuit breakers on all signals governing over them.

93. Cross Protection.

Protective circuits shall be so arranged as to:

(a) Automatically disconnect any unit or units improperly supplied with power.

(b) Prevent the restoration of power until the trouble is removed.

(c) Cause an operative failure in event of any failure in the protective circuit.

94. Switchboard.

The Contractor's recommended arrangement of circuits shall be followed, subject to necessary modification on account of special requirements.

95. Electric Lighting.

96. Special.

Note.—The Purchaser will here indicate in full detail all special circuit requirements.

(a) ....
(b) ....
(c) ....
(d) ....
(e) ....

TRACK CIRCUITS.

100. General.

The Contractor shall provide .... track circuits as shown by the shaded tracks on Purchaser's plans. The purpose or purposes of each track circuit will be indicated on the plan by one (1) or more of the following letters:

Number.

S............for control of semi-automatic signals.
D............in place of or in addition to detector bars.
F............for control of fouling point indicators.
A............for control of annunciators.
R............for control of route locks.
B............for control of automatic block signals.
C............for control of highway crossing bells.

All sidings and siding crossovers shall be protected by shunt track sections extending to the fouling point of derail; main line crossovers shall be protected by as much shunt track section as can be obtained.

101. Bonding.

All rail joints, except as mentioned below, shall be bonded with two (2) No. 8 W. & M. gage (162 in. diameter) E. B. B. galvanized iron wires .... in. long.

Note.—There should be a specification submitted covering the manufacture of the material in the bond wires.

Bond wires shall be located outside of splices and at least one wire shall be on gage side of rails.

Each bond wire shall be fastened at each end into the web of the rail by a channel pin or bonding tube.

Bonding shall be completed on the same day that holes are drilled.

Note.—It is recommended that No. 6 B. & S. gage bare copper or copper-clad bond wires shall be used in tunnels and applied as above mentioned.

It is recommended that at joints in highway and street crossings and in station platforms that two iron or copper-clad bond wires shall be used on gage side of rail and two copper or copper clad wires on outside of rail and applied as above mentioned.

Frogs shall be bonded in the same manner as rail joints and shall be so connected that the continuity of the track circuit will be broken when they are taken from the track.

Pins or tubes shall be made of iron or steel coated with copper or tin and shall be of such length, shape and hardness that when driven into the rail in combination with the bond wire they will completely fill in cross-section a nine-thirty-second (9-32) in. hole in web of rail and will form a good mechanical and electrical connection.

The following types of channel pins or bonding tubes are satisfactory to the Purchaser..............................

....

Pins or tubes will be calibrated by the Purchaser.

A selection will be made from each package of pins for test.

A variation of the thickness of the pin or tube between the base of the groove at the center and the outer wall greater than one-sixty-fourth (1-64) in. will not be permitted, or else a variation either way from the outside diameter of the standard pin or tube at center greater than one one-hundred-twenty-eighth (1-128) in. will not be permitted.

The entire shipment will be rejected should five (5) per cent of the pins or tubes tested prove defective.

102. Insulated Joints.

Insulated rail joints shall be furnished by the Purchaser and installed by the Purchaser at joints designated by the Contractor.

Insulations for bridle rods shall be furnished by the .... and installed by the Purchaser at points designated by the Contractor.

Insulated tie plates and other insulated interlocking connections shall be furnished and installed by the ....

Both rails shall be insulated at fouling points, ends of track circuits and in switch leads.

All rail joints to be insulated are .... lbs. .... section, as shown on attached drawings, and as located on plan of tracks.

All switches to be insulated are equipped with .... bridle rods .... in. by .... in. cross-section, as shown on attached drawings, except as noted on plan of tracks.

103. Track Battery.

Each track circuit shall be operated by at least two (2) cells of gravity battery connected in multiple.

Jars shall be of glass, six (6) in. in diameter by eight (8) in. in height by one-eighth (1/8) in. thick.

Zincs shall be four (4) lbs., circular, amalgamated, with two (2) per cent mercury supplied with brass terminal and suspended from three points; unless other types are specified.

Coppers shall be flat leaf with connecting wire riveted, and shall be so shaped that they will be held in place by the copper sulphate.

Three (3) lbs. of good copper sulphate, free from dust, shall be furnished with each cell.

Note.—Complete specifications for battery materials should be furnished by Purchaser, if practicable.

104. Battery Housing.

Unless otherwise specified, track batteries shall be housed in three (3) cell chutes........ ft. deep, as per
cast iron
concrete
drawing attached, weighing for cast iron not less than three hundred (300) lbs. each. Each chute shall be provided with a three (3) cell elevator, rope, and if specified, a frost board.

105. Relays.

Relays shall conform to specifications of the Railway Signal Association dated October, 1906.

106. Relay Housing.

When possible, relays shall be housed in the signal mechanism case; otherwise they shall be housed in weatherproof
iron
wood
boxes located as specified, in the tower, on signal bridges or on posts.
iron
wood

107. Switch Protection for Non-Interlocked Switches.

Circuit controllers for non-interlocked switches shall have two independent shunt connections to the track circuit of each track made dangerous by the opening of switch. Switch circuit controllers shall be located on the same side of switch as the normally closed point and connected thereto, and shall be arranged to shunt track circuits when point is open one-quarter (¼) in. or more.

108. Connections.

Track batteries and relays shall be connected to the rails by single conductor B. & S. gage, rubber covered,
No. 8
No. 10
soft drawn copper wire. Fouling shunt connections and switch box shunt connections shall be made with two single conductor B. & S. Gage, rubber covered, soft
No. 8
No. 10
drawn copper wire.

Rubber covered stranded wire of .... B. & S. gage shall be used from trunking to track batteries when track batteries are in chutes.

Note.—A minimum gage of No. 12 B. & S. is recommended for such wire.

PAINTING.

110. General.

All materials shall be pure and the quality of paint shall be such as will permit of the application herein specified.

111. Cleaning.

Surfaces covered with rust, grease, dirt or other foreign substances, shall be thoroughly cleaned by scraping or other suitable method before paint or oil is applied.

112. Mixing.

113. Application.

General.—Paint shall not be applied to outside surfaces in wet weather, nor shall any surface be painted until it is cleaned and dried, nor until previous coating has thoroughly dried.

Pigment finishing coats shall be of sufficient body to form an opaque coating.

Finishing coats shall not be applied sooner than forty-eight (48) hours after the previous coating has been applied.

Paints mixed on the ground shall be applied within three (3) hours after the pigment and oil are mixed.

All priming coats shall be applied as soon as is consistent with the progress of the work.

All second coatings shall be applied in sufficient time for

the third coat to be applied and dry when the plant is completed.

Iron Work.—All iron work, except detector bars and finished parts of machine, shall be given one priming of red lead and raw linseed oil and two (2) finishing coats.

The following specific finishing coats shall be used:

	Kind of Paint.	Color.
Signal bridges and brackets......	....	....
Signal masts	....	....
Switch mechanisms and connections	....	....

Wood Work.—Exposed wood work shall be given one priming coat and finishing coats as follows:

	Kind Paint.	Color.	Number Coats.
Home signal blades........	....	....	....
Dwarf signal blades.......	....	....	....
Distant signal blades.......	....	....	....
Trunking, junction boxes, etc.	....	....	....

114. Buildings.

All towers or other buildings in connection with the interlocking plant, if built of wood, shall receive one priming coat and two finishing coats as specified below.

The priming coat shall consist of ...., and, when thoroughly dry, two coats of pure lead and oil, in the following tints, shall be applied:

....

....

....

Prepared paints manufactured by......................

....

....

will be accepted.

120. Special.

SUPPLEMENTARY SPECIFICATIONS FOR DRAWBRIDGES.

130. Locking.

At least one lever of the interlocking machine, called the bridge lock lever, shall be assigned for the purpose of locking the bridge. The bridge lock lever, when reversed, shall be arranged to lock the bridge in the closed position and to prevent the application of power for the purpose of withdrawing the bridge latch or opening the bridge.

The bridge lock lever, when normal, shall be arranged to lock all levers used for bridge protection in the proper posi-

tion to protect the bridge, and also to cut off power from all control wires leading to such functions.

A separate locking arrangement shall be provided for each of the following purposes:

(a) To insure that the bridge is in proper alinement.

(b) To insure that all bridge surfacing devices are in their proper position.

(c) To lock all rails in proper position for train movement.

The Purchaser will supply complete information, including detail drawings, of bridge locking apparatus to be controlled by the interlocking machine.

Note.—It is recommended as a more desirable method of operation that the rails at the end of the draw and on the shore next to the draw be fixed in position and have the necessary locks, and that lifting rails be not used.

THE END.

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